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ABSTRACT

This five-volume course is designed to provide the student with information about fire protection, first aid and rescue, and special situation firefighting techniques. The course is one of number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in civilian setting. The course materials include the following volumes: General Subjects for Fire Protection, Fire Engineering and Investigation, First Aid and Rescue, Fire Protection Vehicles, and Structural Firefighting. Each volume contains reading assignments, review exercises and answers, and an examination. The course is designed for student self-study. (LRA)

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Military Curriculum Materials for Vocational and Technical Education

ED19577
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FIRE PROTECTION SPECIALIST
17-12

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY
1960 KENNY ROAD · COLUMBUS, OHIO 43210

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

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- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
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- Operating information systems and services
- Conducting leadership development and training programs

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Military Curriculum Materials
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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Servi[illegible]

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
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FIRE PROTECTION SPECIALIST
CDC57150

Correspondence Course 17-12

Developed by:

United States Air Force

Development and Review Dates:

July 1979

Occupational Area:

Public Service

Print Pages:

731

Availability:

Vocational Curriculum Coordination Centers

Suggested Background:

None

Target Audiences:

Grades 10 - Adult

Organization of Materials:

Student text with review exercises and answers, and exams covering each volume.

Type of Instruction:

Individualized, self-paced

Type of Materials:		**No. of Pages:**	**Average Completion Time:**
Vol.2:	General Subjects for Fire Protection	158	Flexible
	Exam 2:	15	
Vol.3:	Fire Engineering and Investigation	136	Flexible
	Exam 3:	13	
Vol.4:	First Aid and Rescue	122	Flexible
	Exam 4:	15	
Vol.5	Fire Protection Vehicles	110	Flexible
	Exam 5:	15	
Vol.6:	Structural Firefighting	79	Flexible
	Exam 6:	10	
Vol.7:	Aerospace Vehicle Firefighting	45	Flexible
	Exam 7:	8	

Volume 1 has been deleted due to military specific materials.

Supplementary Materials Required:

None

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION

OSU
The Ohio State University

1960 Kenny Road
Columbus, Ohio 4321
(614) 486-3655

Course Description:

This course is designed to provide the student with information about fire protection, first aid and rescue, and special situation firefighting techniques. The course materials include the following volumes:

Volume 2 -- General Subjects for Fire Protection - covers fire behavior science, hazardous materials identification, fire extinguishers, fire protection hydrolics and prefire plans, fire alarm and communications center, natural cover and miscellaneous firefighting, missile fire protection, and aircraft arresting barriers.

Volume 3 -- Fire Engineering and Investigation - provides information on building construction and design, fire detection and suppression systems, water supply and distribution, fire hazards, fire prevention training and public relations, and fire investigation.

Volume 4 -- First Aid and Rescue - discusses various areas of first aid, transporting of the injured, and forcible entry and rescue.

Volume 5 Fire Protection Vehicles - covers many aspects of vehicle operation and inspection dealt with by a driver/operator of a firefighting vehicle. It covers such areas as driving, vehicle inspection and inspection forms, structural pumper operations, crash, fire, and rescue vehicle operations, and support vehicles.

Volume 6 -- Structural Firefighting - covers the principles of structural firefighting, hose operations, ladder operations, command and control, salvage and overhaul, and training and duty levels.

Each volume contains reading assignments, review exercises and answers, and an examination. The course is designed for student self study. Volume 1 has been deleted due to military specific materials.

FIRE PROTECTION SPECIALIST
CDC 57150

CORRESPONDENCE COURSE

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7. Aerospace Vehicle Firefighting 675
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NOTE: Volume 1 and corresponding test have been deleted due to military specific materials.

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CDC 57150

FIRE PROTECTION SPECIALIST

(AFSC 57150)

Volume 2

General Subjects for Fire Protection

Proficimus More Irretenti

Extension Course Institute

Air University

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PREPARED BY
3340 TECHNICAL TRAINING GROUP
USAF SCHOOL OF APPLIED AEROSPACE SCIENCES (ATC)
CHANUTE AIR FORCE BASE, ILLINOIS

EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

YOU ARE NOW entering into Volume 2 of this CDC. We are pleased that you are progressing in this course and wish to encourage you to continue your efforts and study in order to successfully complete the CDC. You have completed Volume 1 and acquired information on subjects that are general throughout the Air Force, but we emphasized the material in relation to your Fire Protection Career Field.

In Volume 2, we will present much of the knowledge needed to work successfully as a Fire Protection Specialist. This volume will present varied subjects but all are essential in Fire Protection. Subjects covered include Fire Behavior Science, Hazardous Material Identification, Fire Extinguishers, Fire Protection Hydraulics and Prefire Plans, Fire Alarm and Communications Center, Natural Cover and Miscellaneous Firefighting, Missile Fire Protection, and Aircraft Arresting Barriers.

Code numbers appearing on figures are for preparing agency identification only.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTGOX, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 45 hours (15 points).

Material in this volume is technically accurate, adequate, and current as of July 1979.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Fire Behavior Science

QUESTION: SO FAR we have studied the mission and organization of the Air Force, security, safety, publications, supply, supervision, and training. When am I going to learn about firefighting? Isn't that what this career field is all about?

ANSWER: Yes, but to help you learn how to fight fire better, you will need a little better background of knowledge.

Q. Is this the chapter in which I'll receive this knowledge?

A. Partly. This chapter, the chapters you have already studied, and the chapters to come are all preparing you for the final act, which is to fight fire intelligently and efficiently.

Q. Boy, I can hardly wait to get into action. When do we start?

A. Whoa there! Remember, "They also serve who stand and wait." Your job would be much simpler if you didn't have any fires to fight. Don't you agree?

Q. Sure, but what has that got to do with me? I'm a firefighter.

A. By knowing what makes a fire "tick," you can prevent many fires, thus simplifying your job. Gaining knowledge about a subject will not only lead you to understand it better, but also to respect it.

Q. What do you mean understand and respect it?

A. Well, it's something like learning how a car engine runs. Once you have taken it apart, studied it, and put it back together again, you understand how it operates and respect the mechanical precision of its operation. The same is true with fire. By the time you have dug into this chapter, taken it apart, studied it, and reassembled it in your mind, you will understand better just what a fire is. You may also have learned that some of your thoughts about fire were not true. One of the most important items you need to learn is to respect fire rather than to fear it. You can only do this by understanding just what goes on when a fire starts.

Let's go! Anytime I can find a way of doing something easier and better, I'm all for it.

Okay, you will begin now by learning some of the facts about fire.

1-1. Theory of Combustion

What is fire? Sooner or later, you will be called upon to explain fire. The explanations that follow are intended to stimulate you to think. They are also written in a logical sequence so as to be easily understood.

Combustion is a chemical action which produces heat and (often) light. Fire is usually thought of as a result of rapid combustion. In other words, we can say that fire is produced when a material oxidizes so quickly that it produces a lot of heat and a more or less visible flame. So, fire is heat and light together. A more detailed description of fire is offered by the fire triangle and fire tetrahedron theories.

200. State the basic, general principles of chemistry and physics that govern combustion.

Fire Triangle. If, for some reason or another, you do not get enough oxygen, you will die. The same holds true about heat or food. If a fire does not get enough heat, fuel, or oxygen it also will die out. Therefore, to create and sustain a fire, we must have fuel, heat, and oxygen, as shown in figure 1-1.

The fire triangle shows the three elements necessary to cause a fire. Each side is necessary for fire. One side is just as important as either of the other two sides. There cannot be fire without all three parts present at the same time. Using this theory, there are three ways to extinguish a fire: (1) remove the fuel, (2) cut off the oxygen, or (3) reduce the temperature. *Take away any one element and the fire extinguishes itself.* We shall discuss this subject in more detail in the next objective.

Fire Tetrahedron. The fire triangle theory describes the three elements of a fire. Another explanation of the requirement of combustion uses a four-sided figure called a *tetrahedron* as an illustration. Such a tetrahedron is shown in figure

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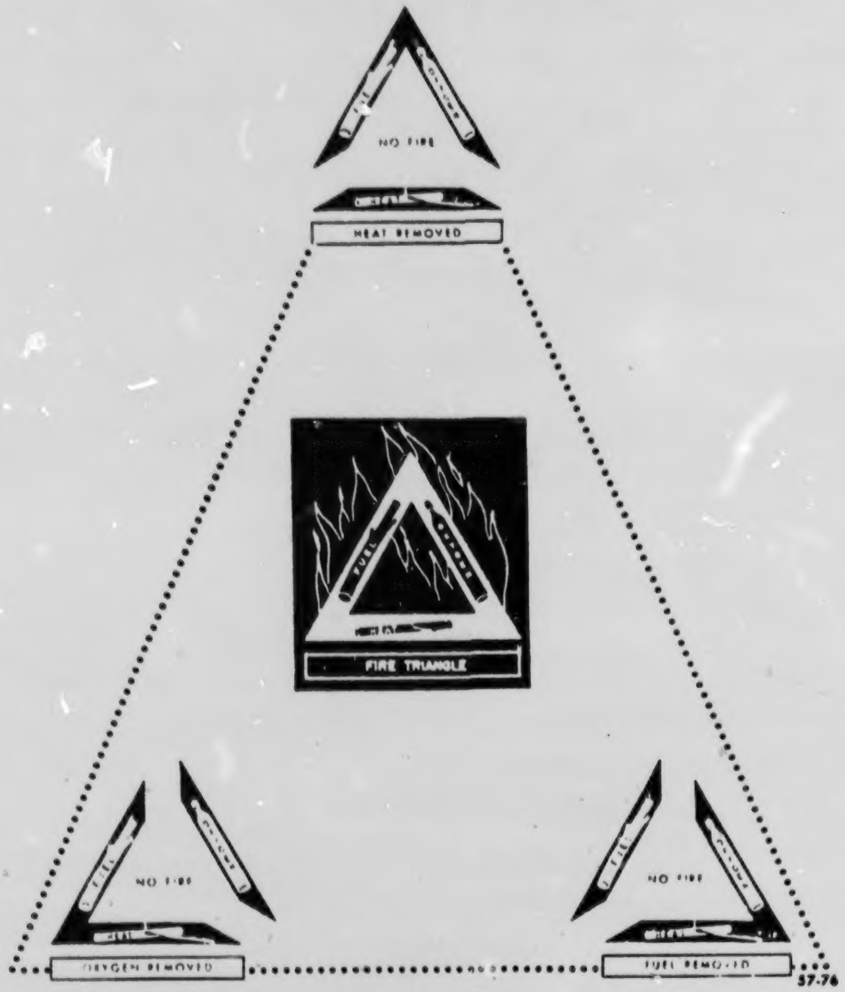


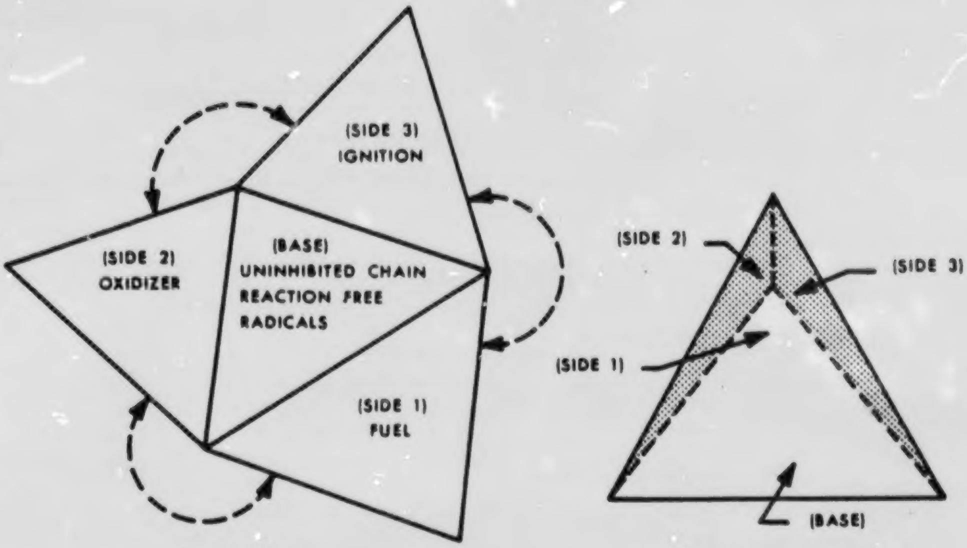
Figure 1-1. Fire triangle.

1-2, A and B. Both theories, fire triangle and tetrahedron, are used to explain what causes a fire.

The fourth element of the tetrahedron fire explanation is known as chemical reactivity, or a *chemical chain reaction*. This chain reaction is best explained in two simple examples, shown in figures 1-3 and 1-4. If you were to ignite the end of any one match, it would burn. In turn, that burning match would finally ignite the ends of the matches touching it. In this manner, the fire would continue to burn and spread until the supply of matches ran out.

Suppose you were to separate or move the match heads from the match ends, as you see in figure 1-4. Now, if you should light the first match, the fire would continue to spread and enlarge until it consumed the last connected match and then would extinguish itself for lack of fuel, even though there were other matches "out of reach." This is a simple way of showing how a chemical chain reaction is stopped.

When a fuel is heated, it gives off vapors which, if mixed with the correct amount of air, can then be ignited by a heat source. Figure 1-5 shows you the formation of fire according to the tetrahedron concept. The pan of fuel shown in figure 1-5 must give off vapors before it can ignite. The vapor area is closest to the fuel. As the temperature of the liquid fuel rises, the molecules of the fuel are more easily released to form vapors. When the heat of ignition is reached, these molecules separate, or break down into elements of hydrogen atoms, carbon atoms, and lighter hydrocarbon molecules, causing these particles to react with the oxygen of the surrounding air. In this area, the oxygen is introduced and begins to mix with these particles, and the reaction between these particles and the oxygen starts. This is the



A. TETRAHEDRON DISASSEMBLED (NO FIRE)

B. TETRAHEDRON ASSEMBLED (FIRE)

Figure 1-2. Fire tetrahedron.

reaction area. The least amount of reaction takes place at the lowest level of the reaction area because there is not sufficient oxygen to react with the hydrocarbon particles. As the number of oxygen molecules increases within the reaction area, the reaction becomes more rapid, until the energy generated by the reactions produces light in the form of flames. The reactions between vaporization and flame production are extremely rapid, even though the flame spread may be slow. The heat and light of a flame are the results of the reaction of the hydrogen atoms, carbon atoms, oxygen atoms, and free radicals chemically uniting and forming new and different compounds.

The outermost edge of the flame is known as the flame front. Beyond the flame front there are not further reactions – only the heat that was generated, water in vapor form, and carbon dioxide escaping into the atmosphere if the combustion was complete. Most fires you will encounter, however, will involve incomplete combustion, producing carbon monoxide and carbon particles along with the heat, water vapor, and carbon dioxide.

What if you should have a fire involving a material other than hydrocarbons (a compound containing hydrogen and carbon only, i.e., acetylene) and oxygen? You would have combustion products composed of the atoms and molecules forming that material, together with the oxidizer used for the support of the combustion. This is the reason a poisonous fuel may give off poisonous fumes and smoke. Combustible material is grouped into one of four classifications. The classes help to simplify firefighting methods and techniques.

Classification of Fire. Materials that make up the different types of fire are grouped in Classes A, B, C and D. By knowing the class of fire a certain material will fall into, you will be able to make intelligent firefighting decisions. Not only must your decisions be intelligent but they must be accurate. Selecting the wrong firefighting technique could be extremely dangerous. For example, as a nozzleman, you might decide to use a straight stream of water to extinguish a gasoline fire. Another error would be to use a water extinguisher on a Class C fire. Not only could such decisions cause much damage but a loss of life as well.

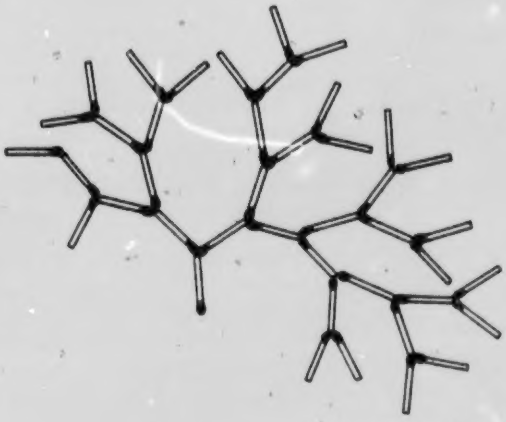


Figure 1-3. Chain reaction.

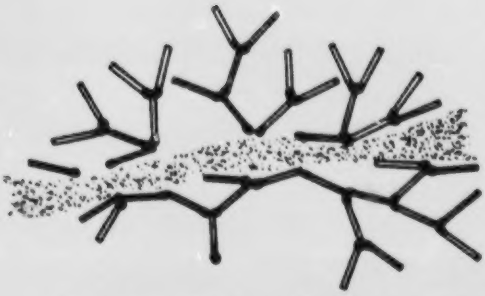


Figure 1-4. Chain reaction interrupted.

Class A. Class A fire materials (fig. 1-6) include vegetable fibers such as wood, paper, cotton, straw, grain, and grass; and combustible minerals such as coal and coke. Nearly all trash fires are considered as Class A.

Class B. Class B fire materials (fig. 1-7) include petroleum products such as gasoline, fuel oils, lubricating oils and greases; animal fats such as butter, lard, and tallow; vegetable extracts such as alcohol, linseed oil, and turpentine; vegetable compounds such as shortenings and oleomargarines; and natural gases and compressed gases such as butane, propane, hydrogen, and acetylene.

Class C. These fires involve electric motors, electrical apparatus, and electrical appliances (fig. 1-8). Actually, a Class C fire is composed usually of Class A or B materials, or a combination of both. As in the example of a burning motor, the motor itself is very resistant to burning, since it is made mostly of cast iron, steel, and copper, but the lubricating oils and wire insulation can burn. Lubricating oils fall into Class B fire material and the insulation may be either Class A or B fire material. The reason for the different classification is the danger from the electricity. Since the electricity can cause injury or death if you "make contact," you should use nonconductive firefighting agents and insulating-type equipment. Water is a conductor of electricity and should not be used.

Class D. Class D fire materials are combustible metals, alloys, or metal compounds, which we will simply call ***metals***. They may be in a solid, semisolid, or liquid state. They may be further reduced in shavings, grindings, granules, or dust. Some liquid metals are kept in a liquid state under pressure. Usually, these liquid metals are extremely dangerous. Some of the more unusual metals are sodium, titanium, uranium, magnesium, and sodium potassium. Some of the more common metals are iron, aluminum, steel, copper and brass.

Remember this: *Any metal, alloy, or metal compound will burn*! The ease of burning depends on the state of the metal. Some metals, such as magnesium, will burn readily from the solid state (fig. 1-9); all of them will burn, sometimes explosively, as dust. A solid steel beam, for all practical purposes, will not burn. Reduce that steel beam to steel wool, filings, or dust, and it burns readily. This fact provides a basic clue to the nature of fire.

Nature of Fire. Even the most flammable materials (capable of being easily ignited) do not actually burn. The vapor given off by a material is the part that burns. When a piece of wood is ignited, the fire is not from the burning *wood*, but rather from the *vapors* that are given off by the wood. The heat causes the substances in the wood to vaporize. The heated vapors mix quickly with oxygen in the air – and fire results. As shown in figure 1-10, this can be demonstrated with a candle. Ignite a candle and allow a few seconds for the paraffin to heat. Place a cap over the candle and allow time for the flame to be smothered. Lift the cap from the candle and note the vapors that rise in a manner very like smoke. Hold a lighted match in the escaping vapors and notice that the flame flashes downward to the candle wick, reigniting it. The tallow or paraffin of the candle is a solid; but when it is heated, it becomes a liquid. From the liquid, as more heat is available, gas or vapors are liberated to sustain the flame at the wick. The following paragraphs explain why this happened. This will help you reach a better understanding of your foe – fire.

Vapor Density. The term used to explain the weight of vapors is "vapor density." In order to

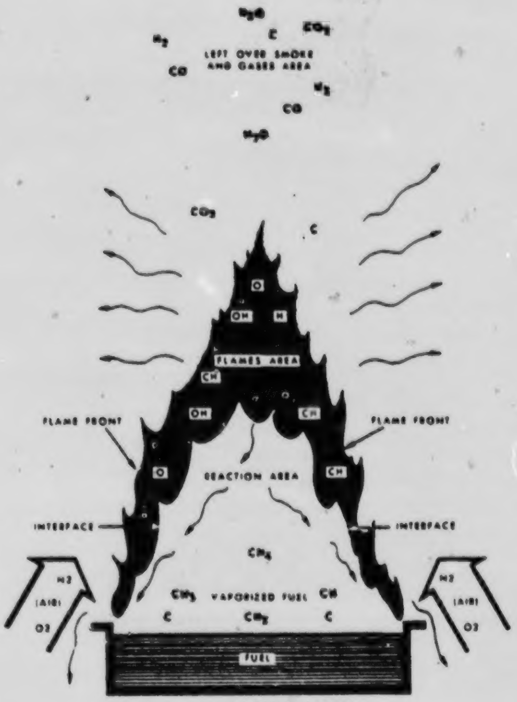


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Figure 1-5. Tetrahedron concept of fire formation.

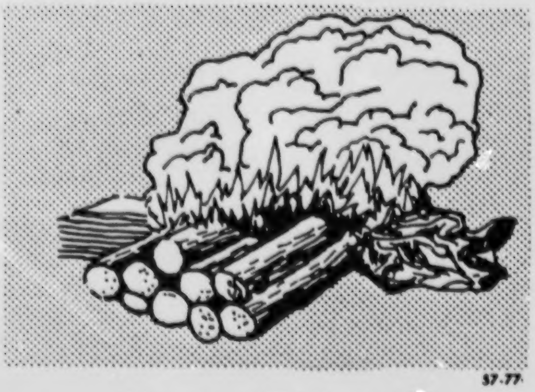


Figure 1-6. Wood (Class A fire).

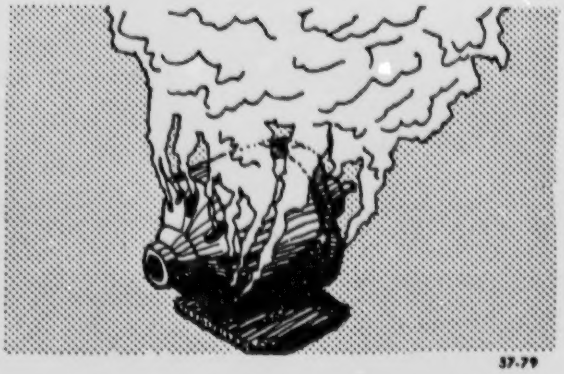


Figure 1-8. Electric motor (Class C fire).

measure the weight of these vapors, we usually compare them to air, which is considered to have a vapor density of 1.00. Therefore, if we say that a substance has a vapor density of 1.5, we mean that it is one-and-a-half times as heavy as air under the same conditions of pressure and temperature. If a substance has a vapor density of .7, it is lighter than air, weighing only 7/10 as much as an equal volume of air. The following chart lists the vapor density (air = 1) for some of the more common flammable materials which you may find on Air Force bases.

MATERIALS	VAPOR DENSITY
Acetylene	0.9
Butane	2.0
Gasoline	3-4
Hydrogen	0.1
JP-4	3.0
Kerosene	3.0
Propane	1.6

The density of gasoline vapors can be shown with a small trough, a candle, and a gasoline-soaked rag, as shown in figure 1-11. A lighted candle (an ignition source) is placed at the lower end of the trough. The rag, soaked in gasoline, is wrung out so that no liquid gasoline will run down the trough to the candle. The rag is then placed in the trough at the high end. Gasoline vapors, being heavier than air, will flow down the trough to the lighted candle, where they will be ignited, then flash back to the rag at the top of the trough. Thus, gasoline vapors, having a vapor density of approximately 3 to 4, will seek the lowest possible level. Gasoline vapors can spread like water and may be ignited at a great distance from their source.

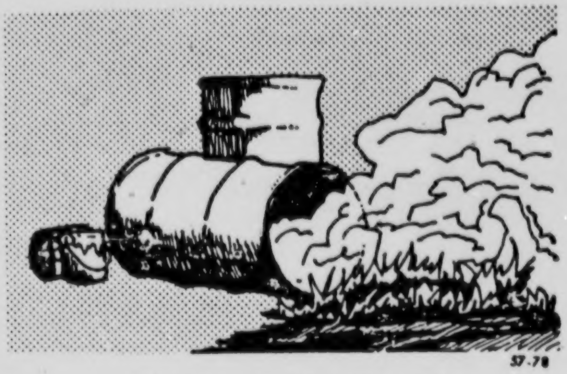
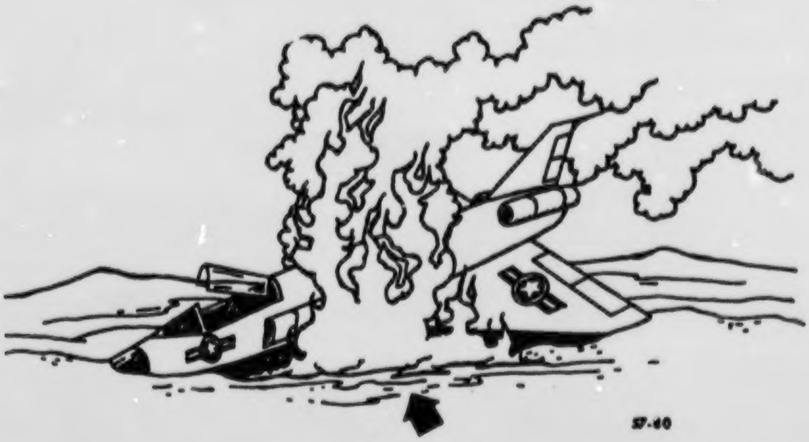


Figure 1-7. Gasoline (Class B fire).

This illustration shows the need for an understanding of vapor densities. As a fire protection specialist, you know that those vapors from fuels with a vapor density of *less* than 1 will collect in high places; those with a density of *more* than 1 will collect in low places; and those with a vapor density *very close* to 1 will circulate and mix with air and will be found at all levels. The examples used in this section to illustrate fuel vapors and vapor density are of the controlled classroom type. These same principles will hold true in actual situations that you will be called upon to prevent and protect against.

One such incident that illustrates these points occurred at a southern Air Force base. The temperature was rather high (about 90° F.), and there was no wind when the incident occurred. An airman, while refueling a cargo-type aircraft, spilled quite a bit of gasoline on himself, the aircraft, and the ground around the aircraft. After securing the gasoline hose in the refueling truck, he walked more than 200 feet to base operations. As he entered the base operations building, he lit a cigarette and immediately was engulfed in flames. Witnesses later said they saw a blue flame race along the ground and ignite the aircraft and refueling truck. The total cost of this incident was one life, one refueling truck, and one aircraft worth over 200,000 dollars. This accident tragically proved under field conditions that it is the fuel vapors that burn, and that the heavy vapors of gasoline lay on the ground, with no breeze to disperse them, to act as a fuse leading back to the aircraft and truck.

1C



BURNING MAGNESIUM (BRIGHT, WHITE FLAME)

Figure 1-9. Burning magnesium (Class D fire).

Magnitude of Fire. The magnitude of a fire means the size of a fire, and it is governed by the surface area of fuel exposed to the air. The magnitude of a fire can be demonstrated with two small containers (containing equal amounts of gasoline) and a small pan, as seen in figure 1-12. No great quantity of fire is created when one container is ignited. If the gasoline in the remaining container is poured into the flat pan and the gasoline vapor is ignited, a larger fire will exist, although the same amount of gasline is used for both fires. This point can be further illustrated by the small quantity of fire given off at any one time from a tightly stacked lumber pile. When this same quantity of lumber is changed into a building, which has a much greater exposure of surface area the fire is of far greater magnitude. The magnitude of a fire is not always determined by the amount of fuel involved, but more often by the amount of fuel exposed to the air.

Flashpoint. The flashpoint of a material is the temperature at which the material is not hot enough to keep burning, but still gives off enough vapors to cause a flame to "flash" across the surface. The fire point of a material is the temperature at which the material will give off ample vapors to keep burning. There is usually about 5° to 10° difference between the flashpoint and the fire point of most materials. Since these two are just a few degrees apart, the term "flashpoint" is used to express the condition of a fuel vaporizing, whether or not it is vaporizing fast enough to keep burning. "Fire point" is the term normally used only when more technical or detailed measurement is required.

Flashpoint can be demonstrated with three open containers, as shown in figure 1-13. One container holds gasoline, one kerosene, and the other alcohol. If you apply a lighted match to each fuel, the gasoline and alcohol will readily ignite; the kerosene will not. Gasoline and alcohol have very low flashpoints. At room temperature, they need no preheating before they reach their combustion points. Fuels having high flashpoints must first be heated to their flashpoint before they will ignite.

The following demonstration, which is shown in figure 1-14, will further show you how flashpoints and fire points are reached. As shown in the figure, hold a lighted match directly above a small block of wood. Note that ignition does not occur. Place the

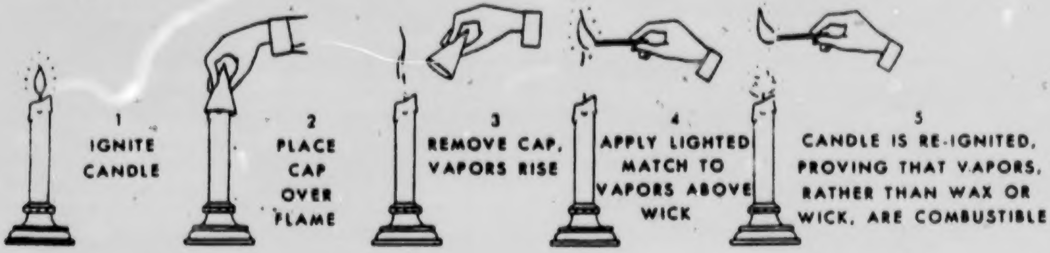

1
IGNITE CANDLE
2
PLACE CAP OVER FLAME
3
REMOVE CAP, VAPORS RISE
4
APPLY LIGHTED MATCH TO VAPORS ABOVE WICK
5
CANDLE IS RE-IGNITED, PROVING THAT VAPORS, RATHER THAN WAX OR WICK, ARE COMBUSTIBLE
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Figure 1-10. Ignition of vapors.

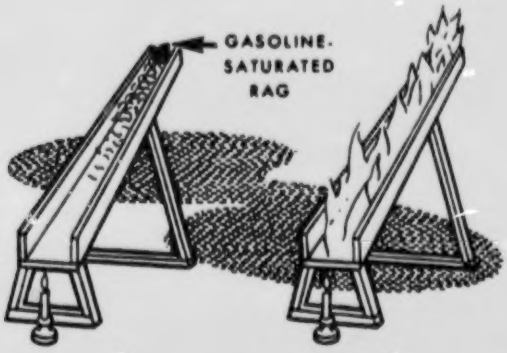


Figure 1-11. Vapor trough.

block of wood on a heating element such as a hot plate, allow sufficient time for the wood to heat and then apply a lighted match to the vapors given off by the wood. The vapors will ignite and flash back to the wood but will not remain ignited, demonstrating that the wood has reached the flashpoint. If the wood is heated further and a lighted match is then applied to the escaping vapors, the wood will continue to burn, indicating that it has reached the fire point.

Ignition Temperature. The ignition temperature is the degree of heat necessary to ignite flammable vapors. This temperature can come from an external source (match, spark, friction); or if the fuel itself is raised to this temperature, autoignition (self ignition) will occur. Look at the following flashpoint and ignition temperatures for some of the more common fuels. You can see that the fuel will give off vapors at a much lower temperature than is needed to ignite the vapors.

FUELS	FLASHPOINT	IGNITION TEMPERATURE
Gasoline: 60 to 80 Octane	-45° F.	536° to 700° F.
JP-4	30° F.	468° F.
Kerosene	100° F.	444° F.
Cleaning solvents	100° to 110° F.	450° F.
*Paper	Approx 250° F. to 300° F.	Approx 475° F.
*Wood	Approx 350° F. to 400° F.	Approx 750° F.

---

*The flashpoint and ignition temperatures will vary because of the many different types of these materials.

Taking gasoline, for example, we find that at any temperature above -45° F., the liquid gasoline is giving off flammable vapors, and that even though these vapors will mix with the proper amount of oxygen and be *ready* to burn, they will not ignite until a source of heat of at least 536° F. is present.

Explosive Limits. The term "explosive limits" means the amount (expressed in percent) of fuel vapor that can be mixed with air to form an explosive or flammable mixture. If less than this amount is used, the mixture will not burn; this is known as too "lean" to burn. If more than this amount is used, the mixture is called too "rich" and will not burn. You have probably heard the expression "the engine is flooded," when an automobile engine won't start. This is an example of a "too-rich" mixture. Figure 1-15 shows how the explosive limits of gasoline vapors can be demonstrated with open containers partly filled with gasoline and a high-voltage spark generator. If the wires from the spark generator are placed into the container close to the surface of the fuel and if the switch button on the spark generator is pushed, we

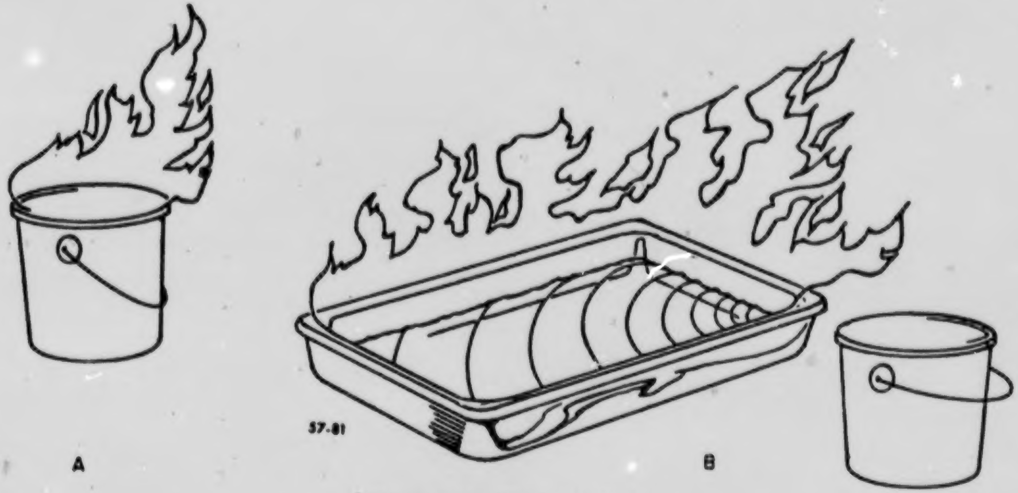
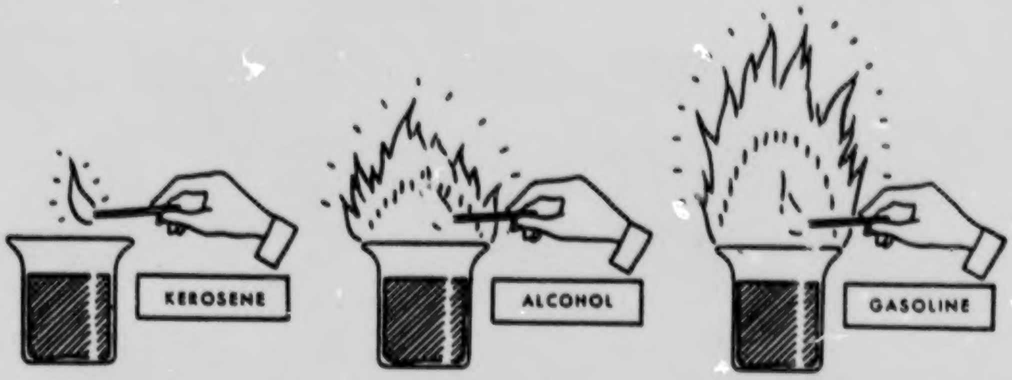


Figure 1-12. Fire magnitude.



KEROSENE WILL NOT IGNITE WITHOUT PRE-HEATING

ALCOHOL IGNITES AT ROOM TEMPERATURE

GASOLINE READILY IGNITES AT ROOM TEMPERATURE

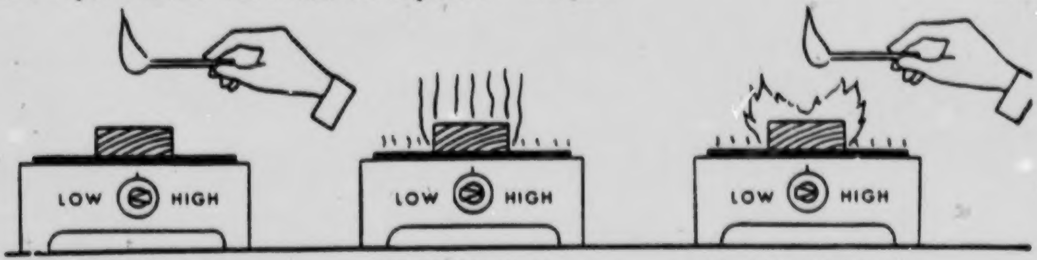
Figure 1-13. Ignition of liquid fuels.

find that the mixture is too rich and the concentrated gasoline vapors will not ignite. Raise the wires from the spark generator 4 or 5 inches above the top of the container, push the switch button on the spark generator, and again the gasoline vapors will fail to ignite. Now the test shows that the mixture is too lean, and indicates the absence of enough gasoline vapors. If, however, the wires are placed in a lower position near the top of the container, and the switch button on the spark generator is pushed, the gasoline vapors will ignite, indicating that at this point, the gasoline mixture is within its explosive limits.

An explosion chamber is also used to demonstrate the explosive range of gasoline and other fuels. The chamber consists of a metal cylinder or pipe, open at one end, with a spark plug inserted on the side. To test a sample of fuel, you could add fuel to the chamber, perhaps one drop at a time. After the fuel vapors and the air in the chamber were completely mixed, you could fire the spark plug. When one, two, or three drops of fuel did not cause an explosion, you would know that the mixture was too lean. Suppose that the mixture exploded with fuel amounts of 4 to 11 drops. The explosive reaction would then indicate that the vapor mixture was within the explosive limits. If 12 or more drops of fuel were placed in the chamber, then no explosion would show that the mixture was too rich. However, if you remove the plug, pour some fuel from the tube, reinsert the plug, and close the switch, the fuel vapors should again explode. This indicates that the vapors once again were within the explosive limits after some of the fuel vapors were replaced by air.

Remember, there is a minimum proportion of vapor-to-air below which the vapor will not burn. There is also a maximum proportion of vapor-to-air above which the vapor will not burn. The minimum (lower) and maximum (upper) limits of the proportion of vapor-to-air in which the mixture will ignite or explode are known as the lower and upper explosive limits. The explosive limits (percent by volume in air) for some of the more common fuels are shown here.

FUEL	LOWER LIMIT	UPPER LIMIT
Acetylene	2.5%	80.0%
Butane	1.9%	8.5%
Gasoline	1.4-1.5%	7.4-7.6%
Hydrogen	4.0%	75.0%
JP-4	1.3%	6.5%
Propane	2.2%	9.5%



NO VAPORIZATION—TEMPERATURE NOT SUFFICIENT

AS TEMPERATURE INCREASES, VAPORIZATION BECOMES VISIBLE

IGNITION OCCURS BY APPLICATION OF LIGHTED MATCH TO VAPORS

Figure 1-14. Vaporization of wood.

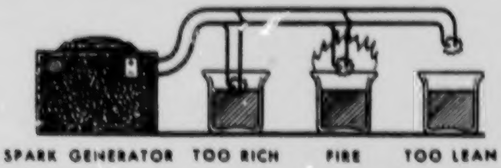


Figure 1-15. Explosive limits of gasoline.

Spontaneous Heating. Spontaneous heating and spontaneous ignition start as a result of a chemical reaction within the material—a reaction independent of any outside source of heat. Spontaneous heating begins a cycle of oxidation that builds up heat very slowly in its first stages. This condition is called spontaneous *heating* until it builds up to a temperature high enough to cause ignition. At this point, it becomes *spontaneous ignition*. In many materials, this process develops slowly and does not reach its ignition point for days or even weeks; consequently, fires may break out today that were actually started days before. Usually there is enough air to allow oxidation, but not enough air to carry the heat from the area. Such conditions are found in large masses of loosely packed materials. With some materials, moisture quickens spontaneous reactions. Most materials that have drying characteristics are subject to spontaneous ignition. Some of the more common materials that may spontaneously heat and ignite are animal oils, mixed fish oils, linseed oil, cottonseed oil, coal, coke, charcoal, sawdust, hay, grain, and cotton.

Propagation of Fire. Propagation of fire simply means the spread of fire. As a substance burns, fire propagation will be increased by the transmission of heat to nearby materials. This heat transmission causes additional vapors to be liberated, thereby spreading the fire. One of the best examples of propagation is a forest fire originating from a carelessly dropped match. Figures 1-16, 1-17, 1-18, and 1-19 show that heat is transmitted by four methods: conduction, radiation, convection, and flame contact.

Conduction. Conduction is the transmission of heat through a conductor, such as a pipe, hot-air duct, wire, or even a wall. For example, when a fire starts in a room, a wall of that room may, without being burned through, conduct enough heat to cause a fire in the next room.

Radiation. Radiation is the discharge and spread of heat from a heated or burning object. This radiation takes place through the air or through space (as from the sun), sometimes causing another flammable object to ignite. For example, when wet clothing is hung to dry over a chair too near a stove, the water evaporates, then the clothing heats to ignition temperature and finally begins to burn. This is caused by heat radiation.

Convection. Convection is the transmission of heat by moving currents of a liquid or gas. When these liquids and gases are heated, they begin to move within themselves; and by their free motion, circulation starts. For example, air becomes heated on a radiator by conduction. Then, because it expands and becomes lighter, it moves upward, and the heavier cold air takes its place and becomes heated. Thus, a continual circulation is maintained until all the air in the room is heated.

Flame contact. Heat may be conducted from one body to another by direct, flame contact (see fig. 1-19). Fire spreads along or through burning material by flame contact. When a material is heated to the point where flammable vapors are given off, the vapors may be ignited. Any other flammable material may be heated to its ignition temperature by direct contact with the flame or burning vapors. Another example of flame contact is lighting an upright candle with a match.

Intensity of Fire. The intensity of a fire means simply how *hot* the fire is burning. You should know that some types of fuels naturally burn hotter (more intensely) than others. For example, a gasoline fire burns hotter than a wood fire, while an acetylene flame is hotter than a gasoline flame. There is another factor that has a bearing on intensity, and that is the amount of oxygen present. For example, acetylene burns with a flame temperature of about 1200° F. when air is the only source of oxygen present; but when the same acetylene is burned in an oxygen-rich atmosphere, the flame temperature may be as high as 6300° F., as noted in figure 1-20. Now you can see that two things determine the intensity of a fire—the type of fuel and the percent of oxygen present.

Oxidation. In nearly all fires, oxidation takes place by using the oxygen that is present in the atmosphere. However, in some cases, certain chemical compounds known as *oxidizing agents* are involved. Though not flammable themselves, when they are heated or when they come in contact with water, they give off oxygen which, in turn, supports the burning of flammable materials. The more common oxidizing agents are the nitrates, chlorates, and peroxides. If a small quantity of potassium chlorate is added to a pile of sugar, flour,

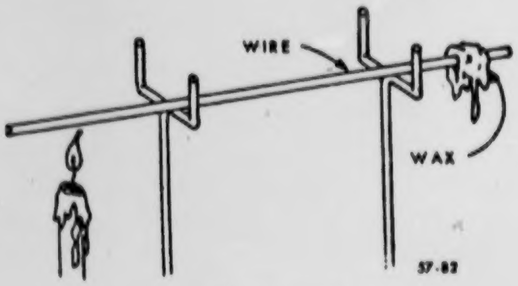


Figure 1-16. Conduction.

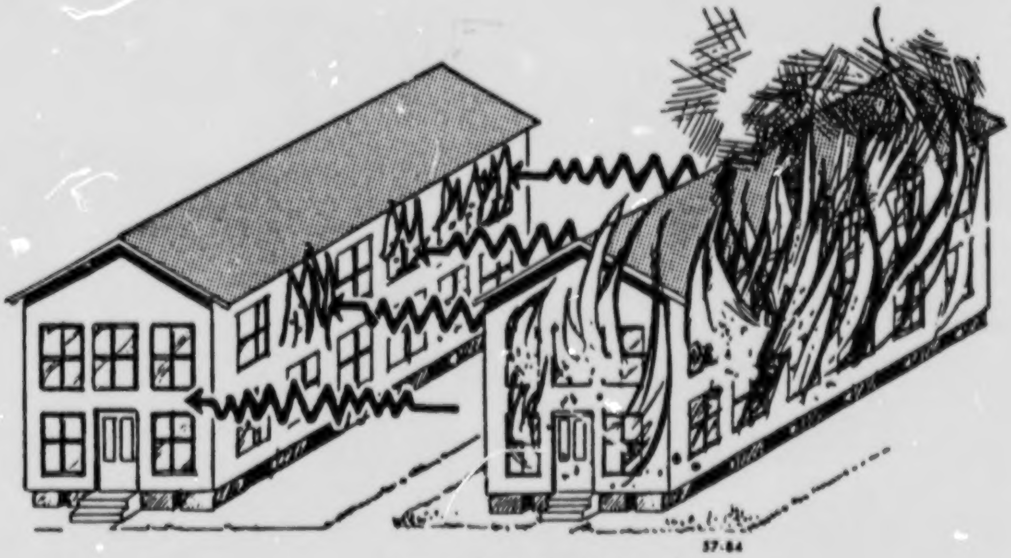


Figure 1-17. Radiation.

or starch, and heat is applied, the mixture will burst into flame and burn violently. Without the addition of the oxidizing agent, these same fuels would be extremely slow in igniting. This brings us back to the point we were making at the first of this chapter when we were discussing the fire triangle. In order to have a fire, three things are necessary: fuel, oxygen, and heat—*the deadly triangle*.

Exercises (200):

1. The fire tetrahedon differs from the fire triangle in that a fourth element has been added. What is the added element?

2. Why does the least amount of reaction take place at the lowest level of the reaction area?

3. What is the composition of a typical poisonous smoke?

4. Why must you know what class of fire a certain material will come under?

5. After you are sure the electricity has been turned off to a burning electric motor, how should the fire be fought?

6. The burning ease of Class D fire materials depends upon what factor?

7. What causes any flammable substance to burn?

8. What does it mean when a substance has a vapor density of 2.5?

9. At what levels would you expect to find fuel vapors having the following densities: (a) 0.99; (b) 1.75; (c) 0.31?

10. The magnitude of a fire is governed by what factor?

11. The term "flashpoint" is used to express what condition?

12. What will happen if the temperature of a fuel is raised to its ignition temperature?

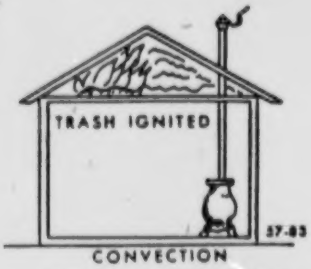


Figure 1-18. Convection.

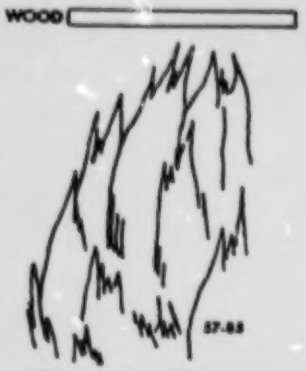


Figure 1-19. Flame contact.

13. The maximum proportion of vapor-to-air, above which the vapor will not burn, is known as ______.

14. Spontaneous heating and spontaneous ignition start as a result of what action?

15. Why do large masses of loosely packed materials readily ignite as a result of spontaneous ignition?

16. Fire propagation will be increased by what action?

17. In an enclosed room, where would you find the coldest air; why?

18. Other than the type of fuel involved, what factor has a bearing on the intensity of fire?

19. What are oxidizing agents and what effect do they have on a fire?

20. What are the more common oxidizing agents?

1-2. Fire Suppression, Control and Extinguishment

Fire suppression means slowing down the rate of burning, whereas control means keeping the fire from spreading or holding the fire to one area. Extinguishment, of course, means putting the fire completely out. You can see that there is quite a different meaning in the terms "suppression," "control," and "extinguishment." Fire suppression

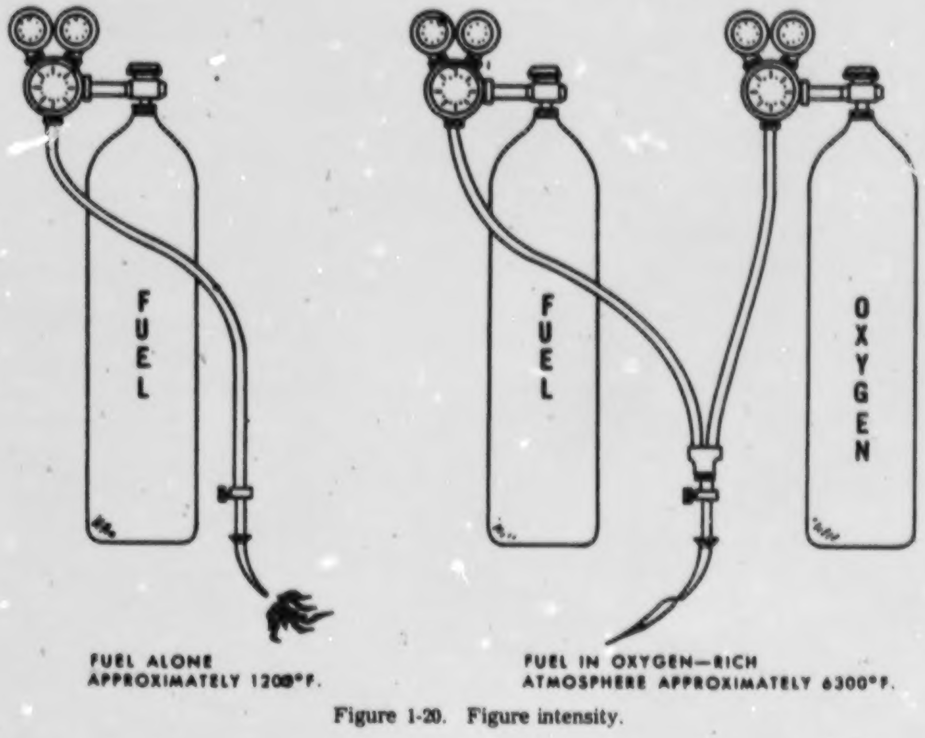


Figure 1-20. Figure intensity.

and control are very important when an aircraft crashes. In most cases, there is not enough water and foam on the trucks to completely extinguish the fire. This is why quick suppression and limited control are of the utmost importance in rescuing crewmembers.

The methods of fire control are extremely important to you as a fire protection specialist. The selection of a method or methods, the manner and order of application, and the resultant degree of effectiveness—these will be your problems throughout your fire protection career. The proper selection of an agent or a method of control or extinguishment may be the most important single factor in determining the degree of success of a firefighting operation.

201. State how each of the four methods of fire extinguishment works.

Under the triangle-of-fire concept, we discussed three ways of suppressing, controlling, and extinguishing a fire: (1) cooling, (2) smothering, and (3) separation. Extinguishing a fire is somewhat comparable to the elimination of life. For example: the cooling of the fire may be compared to asphyxiation (elimination of the oxygen supply), and separation may be compared with malnutrition or starvation. The tetrahedron concept adds a fourth means, chemical reaction.

Cooling. The cooling process uses an extinguishing agent whose primary characteristic is heat absorption (see fig. 1-21). Water is the best general cooling agent for firefighing purposes. Used on Class A fires, the water absorbs the heat generated at the surface of the burning material, thus reducing the temperature of the material below its flash point. Water can also be used on Class B fires, which include flammable petroleum products. As with a class A fire, the water absorbs much of the heat, reducing the vaporization rate of the liquid fuel. This is most noticeable in a fire involving lubricating oil, whose flashpoint is between 300° Fahrenheit and 450° Fahrenheit. It is of less value in a fire involving gasoline, with its flashpoint at -45° Fahrenheit. Water could never cool gasoline below its flashpoint. The extinguishing ability of the water is highest when the water is broken into fine particles to accelerate the heat absorption.

Smothering. Smothering, shown in figure 1-22, excludes the oxygen from the fuel so that the gases or vapors of the fuel cannot ignite and continue the combustion. CO^2 and foam are used for this purpose.

Separation. Separation (or removal) of the fuel, as in the example of turning off a valve in a gas line (fig. 1-23) prevents the fuel and oxygen from coming together. If fuel is not available, then heat, regardless of the temperature, cannot affect the fuel. Therefore, there is no fire.

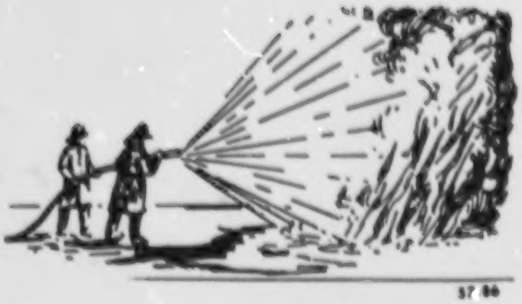


Figure 1-21. Cooling.

These three methods of extinguishment explain how fires are extinguished with the use of water, carbon dioxide, and foam. They do not entirely account for the results obtained by vaporizing liquids or dry chemicals. Vaporizing liquids could not possibly absorb enough heat to have the same effect as water, and dry chemicals do not exclude sufficient oxygen to smother a fire in the same manner as carbon dioxide. Therefore, we must explain the chemistry of fire in terms of the theory of reactivity.

Chemical Reaction. The sequence of events in suppressing or extinguishing a fire with dry chemicals or vaporizing liquids includes some aspects of the first three methods. Using potassium bicarbonate (dry chemical) as an example, you can follow the process of the fourth method of extinguishment, namely, the interruption of the chemical reaction, shown in figure 1-24. (Remember, this is a rapid reaction and doesn't necessarily happen one step at a time.) Now follow carefully.

First, the heat of the fire vaporizes the potassium bicarbonate, thereby producing water, carbon dioxide, and potassium dioxide. In the process of vaporization and the change of these compounds, a substantial amount of heat is absorbed by the powder. Some more heat is also absorbed by the water, and some smothering occurs due to the release of CO^2. Second, the chemical reaction resulting when the potassium dioxide unites with the water formed by the fire creates an amount of potassium hydroxide. The third step is that some potassium hydroxide reacts with certain products released from the fuel, thus forming water and potassium monoxide. Other potassium hydroxide molecules react with the free hydrogen of the combustion to form a potassium atom and a molecule of water. Finally, this combination of reactions halts the process of fuel uniting with the oxygen of the air, thereby breaking the chemical chain reaction and stopping the fire. You should realize that it is not so much the names of the various chemicals in this extinguishing action that are important, but the fact that several actions occur. Each action results in the formation of another controlling agent. The total result, then, is much

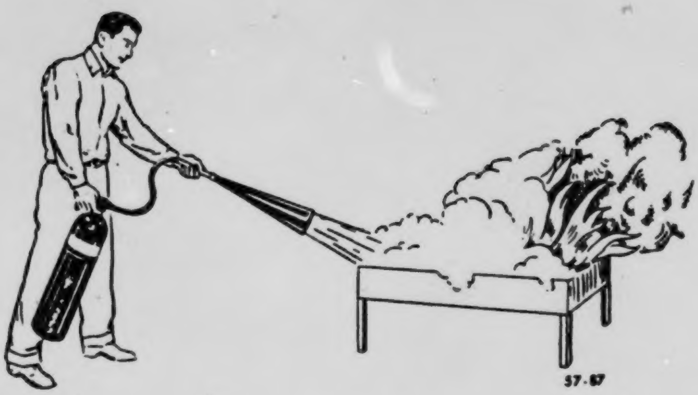


Figure 1-22. Smothering.

greater than we would have obtained with the same amount of a simple agent such as water.

Exercises (201):

1. When is the extinguishing ability of water used on fire at its highest?

2. How does smothering extinguish a fire?

3. Turning off a valve in a fuel line is an example of what method of extinguishment?

4. How does a dry chemical, such as potassium bicarbonate, ultimately extinguish a fire?

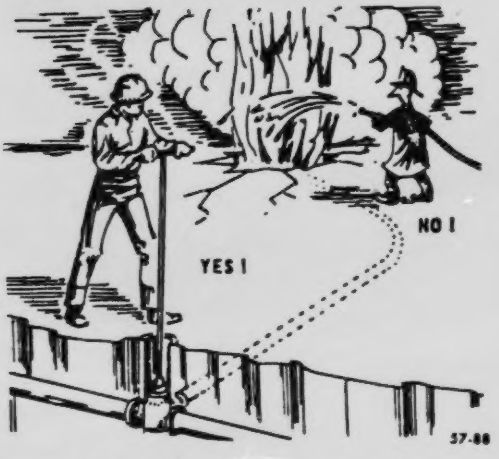


Figure 1-23. Separation (removal).

1-3. Extinguishing Agents

Now that we have discussed methods of fire suppression, control, and extinguishment, let's take a look at some of the agents used by the Air Force. In our discussion of these agents, we will deal with their characteristics, their effect on fire, and the types of fire on which each is used.

202. Identify extinguishing agents by their characteristics and the type of fire on which each is used.

Water. Water is the most commonly used agent in firefighting. In its natural state, it is highly stable and may be used to extinguish most types of fires if properly applied. Due to its conductive properties, water should NOT be used on electrical fires.

Additives. There are many additives for water used in firefighting. Each of these has a specific purpose and effect on the water. Some additives decrease the friction loss in fire hoses, while others increase the penetration capability of water. For a more detailed study of the various additives that you may have an interest in, consult the commercial publications in your fire station.

Cooling. Cooling is one of several ways water extinguishes fires. The outstanding heat absorbing qualities of water make it an excellent cooling agent. In the cooling process, water is applied in large enough amounts to reduce the temperature of the surface of the burning material to below its flashpoint. The amount of water required depends on the burning material (its temperature) and the manner in which the water is applied (straight or fog stream).

Smothering. When water is used to smother a fire, steam must be generated in sufficient amounts to exclude or displace air. If the steam generated is confined in the combustion zone, the smothering action will be enhanced. In ordinary combustibles, the cooling effect of the water - not the smother - normally causes extinguishment. The smothering

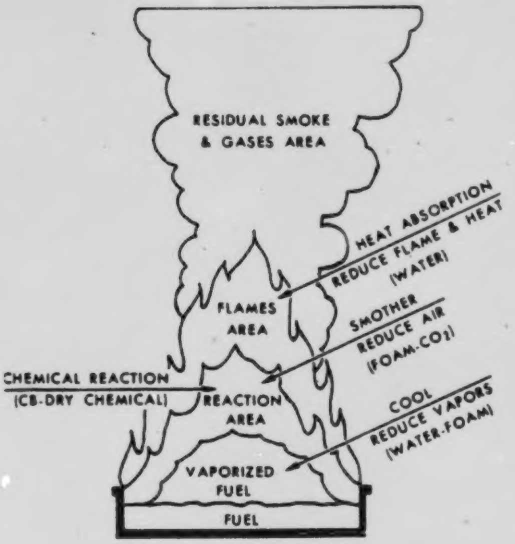


Figure 1-24. Methods of fire suppression.

effect does not completely extinguish the fires; rather, it has a tendency to suppress flaming.

Dilution. In some special cases, water is used to dilute the flammable material to effect extinguishment. When dilution is used, be sure that the material is compatable with water.

Usage. Water is generally used on Class A fires. Fires involving high flashpoint liquids (such as heavy fuel oil, lubricating oil, and asphalt) may be extinguished when water is effectively applied in spray form. Water may also be used to extinguish Class C and D fires in some cases. In these cases, use extreme caution to avoid injury to personnel and/or damage to equipment.

Carbon Dioxide. A number of its properties make Carbon Dioxide (CO^{2}) a desirable extinguishing agent. It is noncombustible and nonreactive with most substances. Carbon dioxide also provides its own pressure for discharge from storage cylinders or extinguishers. Being a gas, carbon dioxide can penetrate and spread to all parts of fire.

Effects. Extinguishment with carbon dioxide is primarily by smothering. It covers the burning materials and reduces the oxygen content to below levels needed for combustion. Even though carbon dioxide is very cold, it has little cooling effect on a fire when compared with equal amounts of water. This is apparent when fires that have apparently been extinguished with carbon dioxide reignite from hot surfaces or embers as the carbon dioxide dissipates.

Usage. Due to its nonconductivity, carbon dioxide is very effective for use on Class C fires. It is also used on Class B fires, but you may also need a blanketing agent on large area fires to prevent reignition. Always use caution around carbon dioxide, as it can cause unconsciousness and death in concentrations needed for extinguishment. A 9 percent concentration is about all most folks can take without becoming unconscious within just a few minutes.

Dry Chemical. The dry chemical extinguishing agents in use today are mixtures of powders and various additives that improve the storage, flow, and water repellency of the powders. Sodium bicarbonate, potassium bicarbonate, and monoammounium phosphate are some of the powders in common use today. Dry chemical is stable at low or normal temperatures, but it has an upper storage temperature of 140° F. At temperatures above 140° F., there may be some sticking or caking. These agents are said to be nontoxic, but in discharge of large amounts they may cause some breathing and visibility problems.

Effects. Flames go out almost at once when dry chemical is applied directly to the fire area; but the exact chemistry and mechanism of the extinguishing action are not fully known. It has been suggested that a chain-breaking reaction in the combustion zone has a greater effect in extinguishment than the smothering or cooling actions and radiation shielding have.

Usage. Dry chemical is referred to in several ways. "Ordinary dry chemical" and "regular dry chemical" generally refer to those powders that are listed for use on Class B or Class C fires. Those powders listed for use on Class A, Class B, and Class C fires are referred to as "multipurpose dry chemical." You must be careful not to confuse "ordinary, regular, or multipurpose dry chemical" with "dry powder."

Dry Powder. Dry powder is a generally accepted term for agents used to extinguish combustible metal fires. No one dry powder has been found to be effective on all types of combustible metals. (We have neither the time or space to go into a detailed discussion of the many different extinguishing agents or the combustible metals on which they are used. For further study of these agents, consult the commercial publications in your fire station.)

Effects. Dry powder generally extinguishes fires by excluding air from the combustible metal. To some extent, heat is absorbed by the powder to lower the temperature of the metal to below ignition point (as with G-1 powder).

Usage. Dry powder is used primarily on Class D fires and should not be used on other type of fire, due to its limited value on these fires.

AFFF. Aqueous Film Forming Foam (AFFF) has replaced protein based foam for all-around firefighting purposes in the Air Force. Protein foam is now used primarily for runway foaming operations (and for some training purposes) and will not be a subject for discussion here.

Effects. The quick "knock-down" and "heat reduction" properties of AFFF have proven it to be a highly effective agent. These properties, combined with its ability to seal the surface of burning hydrocarbon fires to prevent "flashbacks," make it an outstanding extinguishing agent with which to work. When AFFF is applied to the surface of a flammable liquid fire, the surface-active material (surfactant) provides a vapor sealing effect. This not only extinguishes the fire but also prevents the release of fuel vapors which could result in "flashbacks." This vapor-seal is also very hard to break-up by walking, or moving hose lines, through it.

Usage. As with any other extinguishing agent, its effectiveness depends on proper application. The AFFF in use with the Air Force is designed to be applied as a 6 percent mixture (94 parts water to 6 parts AFFF concentrate). This mixture should be applied in a rainfall, or lobbing, effect to allow rapid spreading over the surface.

AFFF is used primarily on Class B fires. It may be used on Class A fires but may be less effective than plain water. Also, keep in mind that foam spray (fog) is more conductive than plain water fog, because the material contained in the foam allows the water to conduct electricity.

Halogenated Agents. Halogenated agents, known as Halons, have been with us for over 50 years. Continuous research has brought these agents to the present high degree of effectiveness they possess along with a decrease in life safety hazard. The older (more well known) agents such as carbon tetrachloride (Halon 104), and chlorobromomethane (Halon 1011) are less effective and more toxic than the newer agents now in use. Halon 1211 (Bromochlorodifluoromethane) and Halon 1301 (Bromotrifluoromethane) are in use by the Air Force today and will be the subject of our discussion. NOTE: Halogenated agents should be referred to by their Halon number to prevent use of confusing abbreviations or chemical names.

Halon 1211 is a gas at normal temperatures but, with its relatively high boiling point (+25° F.), requires pressurization to expel it at a satisfactory rate for extinguishment. Halon 1211 is discharged both partly as a liquid spray and partly as a gas.

Halon 1301 is treated as a liquified gas and, like carbon dioxide, requires no pressurizing agent for expulsion at normal temperature. Nitrogen may be added to storage containers when temperatures are below 0° F. to ensure adequate discharge pressure. Halon 1301 is the least toxic of the Halons. This low toxicity allows for safe discharge from total flood systems in occupied spaces such as computer rooms.

Effects. It appears that these agents cause a "chain breaking" reaction in the combustion process. The mechanism of extinguishment by these agents is not fully understood and remains under study today.

Usage. Halogenated agents are very effective on Class B and Class C fires and have some success on Class A fires. If you are interested in a more detailed study of these agents, consult the commercial publications in the fire department.

Exercises (202):

1. What factor makes water such an excellent firefighting agent?

2. What determines the amount of water needed to extinguish a fire?

3. Why is carbon dioxide so effective for use on Class C fires?

4. What sometimes causes fires to reignite when carbon dioxide is used in extinguishment?

5. Why are additives used in dry chemical agents?

6. What can happen to dry chemical agents when temperatures above 140° F. are reached?

7. What agents should be used in fighting combustible metal fires?

8. How do dry powder agents extinguish fires?

9. What determines the effectiveness of 6 percent aqueous film forming foam on a fire?

10. What are the advantages, if any, of the vapor-sealing effect of AFFF?

11. Why is pressurization needed for Halon 1211?

12. How is Halon 1301 treated?

13. Match the extinguishing agents listed in column B to the class of fire they best extinguish listed in column A. Place the letter(s) of the column B item beside the number in column A. Each agent may be used once, more than once, or not at all.

	Column A		*Column B*
_(1)	Class A fires	a.	Water
_(2)	Class B fires	b.	Carbon dioxide
_(3)	Class C fires	c.	Dry chemical (regular)
_(4)	Class D fires	d.	Dry powder
		e.	AFFF
		f.	Halon 1211/1301

1-4. Characteristics of Flammable Materials

A fire protection specialist must be able to determine the classification of a fire in order to select the best agent to apply and the best method of extinguishment to use. At this point, you know which agents to apply to a particular class of fire. In a real fire situation, however, such as a building fire, you may never fight a single class of fire, but a combination of classes. Buildings are made of many kinds of materials, such as wood, masonry, steel, and tile. Almost all buildings are provided with electricity, and some buildings have gas stoves and furnaces, so that when you respond to a building fire you may come up against a combination Class A and B fire, or a Class A and C fire, or perhaps a Class B and C fire. There is a very good chance that you will sometimes have to fight a combination Class A, B, and C fire.

Aircraft fires or crashes may represent many fire combinations, because all aircraft use some kind of flammable fuel. With all the electrical equipment on board, you have the extra hazard of a Class B and Class C fire. You also have the danger of a Class D fire, because certain parts of the aircraft are made of alloys such as aluminum and magnesium. In this section, we will discuss some of the characteristics of flammable materials. We will also discuss some of the problems of dealing with combustible metals and pyrophoric liquids.

203. Identify flammable materials by their state and describe their hazards.

The differences between materials that will burn are important to you. Simply knowing that a material will burn helps very little. "Wood will burn" is a general statement. The kind of wood – hard or soft – thick or thin – helps you to know when and how fast it will burn. This still doesn't give you enough information on flammable material. Suppose more facts are given you, such as the size of the wood articles (logs, boards, shavings, sawdust, or sanding dust), and whether dry, wet, unpainted or painted. If the wood is painted, is it flammable paint or a fire-retardant paint? Is the wood treated, and if so, for what reasons? This information – though helpful – still isn't enough, as you will discover in this section.

Petroleum products are those which are manufactured from crude oil, which is pumped from deep in the earth. This crude oil, as it comes from the ground, has weight, can burn, can be vaporized, has color, pours less easily if chilled, and has many other means of identification, including smell. The products made from crude oil, such as gasoline, oils, greases, and tars, also have many points of identification. These are, in a general sense, much the same. However, if you were to say that crude oil and gasoline are identical because they both can burn, you would not be distinguishing between two materials. Both materials can vaporize, but that doesn't make them alike, either. Therefore, we cannot identify a product by its general properties until the product is broken down into its specific temperatures, weights, colors, etc. The specific differences in the properties are known as characteristics, and all flammable materials have characteristics peculiar to themselves.

All matter, including flammable matter, will exist in at least one of three states. These states – or groups – are known as gases, liquids, and solids. Some liquids vaporize so easily that they are more often called gases, and on the other hand, some gases can be reduced to a liquid very easily and are often mistakenly called liquids. Some liquids are very thick, and a sharp line cannot be drawn between some liquids and solids. In any case, the actual state is determined by the combination of temperature and pressure of the matter.

As a firefighter, you should know the contents of a container to determine the pressure buildup when the container is near a fire. Too high a pressure is liable to burst the tank or otherwise endanger your life. Liquids are defined as fluids that do not generate more than 40 psia when heated to 100° F. (Psia is pounds-per-square-inch absolute, and is read on an absolute pressure gage or found by taking the sum of the regular gage and atmospheric pressures.) To determine whether a fluid should be classed as a gas or as a liquid, it is tested. The test begins by placing the fluid in a closed container equipped with a pressure gage, then raising the temperature of the container and contents to 100° F. As the fluid vaporizes and creates a pressure, the gage will show it. By adding the gage reading to the atmospheric pressure, an absolute pressure reading is obtained. Suppose the gage reading is 29 psi and atmospheric pressure is the normal sea-level pressure of 14.7 psi. The total would be 43.7 (29 + 14.7) psia. This would identify the fluid as a gas (over 40). If the gage reading were 25 psi and the atmospheric pressure 14.7, the sum would be 39.7 (25 + 14.7) psia. The fluid then would be just within the liquid class.

Flammable liquids. Flammable liquids are those liquids with a flashpoint below 100 ° F. and a vapor pressure not over 40 psia at 100° F. They are called *Class I* liquids, which are subdivided into IA, IB, and IC, as follows:

- Class IA – Any liquid that has a flashpoint below 73° F. and boiling point (BP) below 100° F.

- Class IB – Any liquid that has a flashpoint below 73° F., and a boiling point at or above 100° F.
- Class IC – Any liquid that has a flashpoint below 100° F. but not below 73° F.

Combustible liquids. Combustible liquids have a flashpoint at or above 100° F. Their subdivisions are:

- Class II – Any liquid having a flashpoint at or above 100° F. and below 140° F.
- Class IIIA – Any liquid having a flashpoint at or above 140° F. and below 200° F.
- Class IIIB – Any liquid having a flashpoint at or above 200° F.

Gases. Gases are classified by their chemical properties, physical properties, and usage.

Chemical properties. The chemical properties of gases are of prime interest to firefighters, as they reflect the ability of the gas to react within itself or with other materials. The chemical properties of gases may be broken down as follows:

- Flammable gases – Any gas which burns in normal concentrations of oxygen in the air. These gases are subjected to the same conditions as flammable vapors (flammable range and ignition temperature).
- Nonflammable gases – Any gas that will not burn in air or oxygen. Some of these will support combustion and are called oxidizers. Those that do not support combustion are called inert.
- Reactive gases – Any gas that will react within itself or with other materials under conditions other than fire, i.e., shock, heat, etc.
- Toxic gases – Any gas that may complicate firefighting efforts due to its serious life hazards.

Physical properties. The physical behavior of a gas, both inside its container and when accidentally released, are of prime interest to firefighters. The physical classifications are:

- Compressed gases – Matter which exists solely in a gaseous state in its container with a lower pressure limit of 25 psig (pounds per square inch gage) at normal temperature (70° F.- 100° F.).
- Liquefied gases – Matter which exists partly as a gas and partly as a liquid at normal temperatures inside the container, and remains under pressure as long as any liquid is in the container.
- Cryogenic gases – Gas which remains as liquefied gas in its container at temperatures far below normal temperature.

Usage. A far less rigorous classification of gases is made by their usage. However, there will be much overlapping in these usages.

- Fuel gases – Gases which are burnt with air to produce heat, power, or light.
- Industrial gases – Gases used in industrial processes such as water treatment, welding and cutting, refrigeration, etc.
- Medical gases – Gases used for medical purposes such as respiratory therapy and anesthesia.

Solids. Combustible solids are those which ignite, burn, and change chemically when subjected to heat or fire. The heat must be approximately 350° F. or higher. Above this temperature, ordinary materials will give off enough vapors or gases to burn. Examples with which you are familiar are wood, paper, and cloth. There are other combustible solids which may ignite or detonate at lower temperatures. These are classed as hazardous chemicals and should be kept in suitable containers. They should also be separated from other materials which react with them.

Combustible Metals. Most of the combustible metals are chemical elements which are part of the earth's composition. Very few, if any, are found in the natural state, as is gold. The pure metal is extracted from mineral ore deposits by chemical processes. Some of the combustible metals are sodium, titanium, uranium, zirconium, lithium, magnesium, potassium, and sodium-potassium alloys. Most of the fire hazards associated with combustible metals are in the manufacturing processes. The hazards you might face are normally in the finished products located on an aircraft or missile, or in storage or transportation.

Solids, combustible and noncombustible, are used as construction materials. The effect that fire may have on the different types of materials used in construction is your next subject.

Exercises (203):

1. If a fluid generates 27 psi at 100° F. and at sea level, is it considered a gas, or a liquid?
2. What is a flammable liquid?
3. What is a combustible liquid?
4. How are gases classified?
5. Define a combustible solid.
6. Where are most of the hazards associated with combustible metals found?

1-5. Fire Effects on Building Materials

Building materials have varying degrees of resistance to fire, depending on their composition, arrangement, and the amount of heat generated in the fire. There is no such thing as "fireproof," since all building materials are affected by fire. Other factors, such as density, thickness, building protective devices and surface treatment, result in differing effects on building materials under fire conditions. These factors influence the rates of flame propagation and initial ignition.

204. Cite the effects of fire on various given materials.

Wood. Wood burns with an open flame or it chars, depending upon its type, condition, thickness, etc. Generally, laminated wood girders, etc., will burn more readily than solid timbers of the same dimensions. Wood shingles will burn readily, and under certain conditions will curl and fly off a roof or wall, spreading fire in all directions. Ordinary plywood under fire conditions has a tendency to "unpeel," exposing fresh surfaces to a fire; generally, plywood will burn through more quickly than a solid board of the same thickness. The exterior and marine grades of plywood use binder resins which have some fire resistance, and therefore will not burn as rapidly as the ordinary grades.

Steel. In its usual form, steel is a noncombustible; however, steel wool and filings can be ignited under certain conditions. Under fire conditions, structural steel may heat rapidly, lose its strength, and deform. Corrugated steel sheeting, usually galvanized or coated with asphaltic compounds is extensively used for siding and roofing. Some of the other asphalt-coated types will ignite, and the burning asphalt has a tendency to melt and run, rapidly spreading a fire. All sheet-metal panels, siding, roofs, and partitions tend to deform under fire conditions.

Masonry. Generally, brick, stone, and concrete are considered fire-resistant. Under conditions of prolonged, intense heat, all may crack or spall (crumble). If suddenly cooled, as by the water of a hose stream, the surface of a heated masonry wall may crack or spall with near-explosive force and destructive effects on the wall.

Miscellaneous Construction Materials. In addition to the three most common building materials just covered, there are a number of other materials that are sometimes used in and on Air Force buildings. These materials are normally used for interior finishes, roofing, or decorative effects.

Plastic sheeting. Translucent, corrugated, plastic-impregnated Fiberglas panels are being used for natural illumination of structures. Their combustibility varies according to the type of plastic used as a binder. The length of panels is limited by construction directives. Most types are slightly less combustible than wood, but still burn readily.

Glass. While glass is noncombustible, its normal brittleness is increased by sudden cooling. This causes it to crack and shatter. Under conditions of elevated fire temperatures, glass, whether in the form of window panes or blocks, may melt and run.

Cement-asbestos materials. Corrugated sheeting is used for roofing and siding; smooth and textured sheets are used for interior finish and wainscoting. All are noncombustible; however, like concrete surfaces, these materials are subject to cracking, chipping, and splintering if suddenly cooled.

Asphalt-asbestos siding, roofing, and shingles. All of these are combustible to a degree, depending on the relative amounts of asphalt and inert mineral compounds in their makeup.

Clay tile. In various forms for floor covering, partitions, flues, etc., tile can generally be classed with masonry as noncombustible. Under fire conditions, its behavior is similar to masonry, depending upon its thickness, density, and surface texture.

Fiberboard. Fiberboards of vegetable or animal materials are generally combustible, while those of mineral origin are not. Unless specially treated to retard flame spread, they decompose readily under heat and emit flammable gases with a correspondingly high rate of flame propagation. Certain compressed, hard-surfaced boards composed of wood fiber with phenolic binder materials can be considered slow-burning. The so-called "marine" or "tempered" hardboards are in this slow-burning category.

Gypsum board. Widely used as an interior finish for partitions, walls, and ceilings, gypsum board may be regarded as noncombustible. Under fire conditions (especially if it cools suddenly) it may crack and splinter or chip. When it is installed over wood studs in an approved manner, gypsum board protects one face of the combustible material.

Plastics and synthetic resins. Many types and forms of plastics and synthetic resins are being used as building materials, and for related purposes. Their behavior under fire conditions varies widely, according to their chemical composition, ranging from essentially noncombustible through slow burning, to highly flammable. Examples of these materials (arranged in increasing order of flammability) are Bakelite-type (phenolic) materials, poly-vinyl plastics, and celluloid-type materials. No general rule of fire behavior can be established for these materials. Likewise, toxicity of their burning waste products varies with their chemical composition.

Acoustical and insulation materials. Generally, acoustical and insulation materials composed of animal or vegetable materials are combustible, while those of mineral origin are not. Under fire conditions, even those normally regarded as noncombustible may be disintegrated or severely damaged by relatively little heat. However, some acoustical tiles, when used with approved assemblies, provide 1-, 2-, and 4- hour protection against the passage of flame.

Fire-Retardant Treatment. The two general types of fire-retardant treatment for combustible materials are surface coatings and impregnation. The surface coatings, usually in combination with a paint, decompose at the point of contact of a flame or other heat source to form a blister filled with an infinite number of tiny bubbles. These bubbles insulate that point against further effects of heat until additional flame contact decomposes and disintegrates the blister. Impregnation is usually done at a processing plant or factory by forcing solutions of fire-retardant chemicals, under pressure, into the pores of the material to be protected. Both treatments are of varying effectiveness, depending on the material to be treated, the chemicals used, and the efficiency of the coating or impregnation. Neither is considered to be the equal of noncombustible construction. Some other solids, combustible metals in this case, are often used as construction material. A couple of examples are magnesium and titanium.

Exercises (204):

1. What type of plywood has a tendency to "unpeel" under fire conditions?
2. What happens to structural steel under fire conditions?
3. What special fire hazard is associated with asphalt coated corrugated steel?
4. What may be expected to happen to masonry walls that have been exposed to prolonged intense heat and then suddenly cooled by a hose stream?
5. What governs the combustibility of plastic sheeting?
6. What material, installed over wood studs in an approved manner, protects one face of the combustible material?
7. Give an example of a noncombustible, a slow-burning, and a highly flammable plastic or synthetic resin.
8. Which acoustical and insulation materials are combustible?
9. What are the two types of fire retardant treatments for combustible materials?
10. Name the combustible metals often used as construction material.

CHAPTER 2

Hazardous Material Identification

AS A MEMBER of a fire organization, whether you are an "old hand" or a "new troop," you must set examples for others to follow. This "example setting" is never more demanding than when applied to the subjects of explosives and/or hazardous material. These areas present two special problems.

First, there is the life hazard created by these materials. No other area of fire protection creates such a dangerous situation for the firefighter as when he is involved with the various types of dangerous materials used or transported by the Air Force. Secondly, there is the problem of a lack of knowledge and experience. You can be trained to combat structural and aircraft fires by actually fighting fires under controlled conditions. You can thus gain experience, skill, and knowledge in comparative safety. Most of the conditions can be controlled by the individuals conducting the training. On the other hand, it is next to impossible to present a realistic training situation with materials that are dangerous, explosive, and/or unpredictable.

Since you can be given little training in this area, your knowledge of the subject will come from two sources. First, your OJT trainer and supervisor will be able to pass along their knowledge and the results of their experience to you. The other source is publications, such as this one. As you can see, your experience in this area will be limited, and for this reason, it is very important that you be as well-versed as possible.

2-1. Hazard Classification and Symbols

Until mid-1976, the Department of Defense used a hazard classification and identification system all its own for explosives and other dangerous materials. After many years of study, the Department of Defense (DOD) implemented the present classification system based on a system recommended for international use by the United Nations Organization (UNO). Although the UNO system consists of nine classes of dangerous material, DOD has implemented only two of the nine classes at this time. The two classes are Class 1, "Explosives," and Class 6, "Poisonous (Toxic) and Infectious Substances." Even though only two classes are presently being used by DOD, the doors remain open for the implementation of any or all of the remaining classes at a later date.

The hazard symbols recommended by the UNO system may be compared to the international road signs now in use. Once you know what each symbol/shape stands for, you can recognize the hazards associated with that symbol no matter what country you may be in.

205. Indicate whether given statements correctly reflect Department of Defense (DOD) hazard classes. If a statement is invalid, correct it.

Hazard Classes. As we said before, there are nine UNO classes for dangerous materials. To date, the Department of Defense has implemented only two of these nine classes (Classes 1 and 6). The following is a listing of all nine of the UNO classes of dangerous materials.

Class 1 -	Explosives.
Class 2 -	Gases: Compressed, liquefied or dissolved under pressure.
Class 3 -	Flammable liquids.
Class 4 -	Flammable solids.
Class 5 -	Oxidizing substances and organic peroxides.
Class 6 -	Poisonous (Toxic) and infectious substances.
Class 7 -	Radioactive substances.
Class 8 -	Corrosives.
Class 9 -	Miscellaneous dangerous substances. (Substances which present a danger not covered by the other classes.)

It should be noted that there are some items which should be placed in classes other than Class 1. However, since DOD has implemented only Class 1 for explosives, Class 1 assignments have been made. For example, BLU-27 fire bombs without explosive components installed should belong in Class 3, while WP M23 igniters belong in Class 4. However, in order to maintain identity, items are placed in Class 1 for storage. This may change as other classes are implemented by the Department of Defense.

Divisions. The two "classes" (1 and 6) implemented by DOD are further subdivided into "divisions" based on the character and predominance of associated hazards and on the potential for causing personnel casualties or property damage.

Class 1 - Explosives. Class 1 is divided into four divisions which indicate the types of hazards expected. When the materials classes/divisions are given together the numerical designations of the class (first number) and division (second number) are separated by a period or decimal point (.) as shown in the following paragraphs. In talking about the hazard classes/divisions, refer to them as "Dangerous material, Class 1, Division 1" or "Class Division 1.1 dangerous material." The following is a listing of the four "divisions" of Class 1 materials.

a. Class Division 1.1 Class 1, Division 1 includes mass detonating explosives comparable to Quantity-Distance (Q-D) Class 7 and (M) designated items. Items assigned to this class are principally a blast hazard. They may be expected to mass detonate when a small portion is initiated by any means, such as fire, severe concussion or impact, impulse of an initiating agent, etc. Such explosions normally cause severe structural damage to adjacent objects. Explosion propagation may occur immediately to other explosives stored near (and not adequately protected from) the initially exploding stack. The time interval is short enough so that two or more quantities must be considered as a single explosion for quantity-distance purposes.

There is a possibility that entire stacks of some items in classes 3, 4, 5, and 6 may also mass detonate in the same manner as Class 7 explosives. These items will be identified in stocklists and TOs as belonging to either Class 3(M), 4(M), 5(M), or 6(M).

b. Class Division 1.2. Class 1, Division 2 includes non-mass detonating, fragment producing explosives comparable to Q-D Classes 3, 4, 5, and 6. These are items for which the principal hazards may be fragments, toxicity, or blast (either individually or in combination) depending on such factors as storage configuration, type of packing, and quantity. The protection provided by the inhabited building distance is based on the range of the primary hazard. Most fragments produced by incidents in these classes will fall within the specified inhabited building distance. The fragment distance within a specific class can be expected to vary with type of item and the environment. However, under identical conditions, the distance fragments will travel from one or many items of a given type will be about the same. Items in these classes may explode or detonate progressively if they are involved in a fire or are otherwise initiated.

c. Class Division 1.3. Class 1, Division 3 includes explosives that present a mass fire hazard comparable to Q-D Class 2. Items assigned to this class usually burn vigorously with little or no possibility of extinguishing fires that have gained headway in storage situations. Explosions normally are confined to pressure ruptures of containers, and do not produce propagating shock waves or damaging blast pressures beyond the specified magazine distance. A serious fire-spread hazard can exist from projected burning fragments of propellant, incendiary materials, packing materials, etc.

Toxic hazards normally will not exist beyond the specified inhabited building distance. Examples of explosives in this class: Military pyrotechnics; solid propellants in bulk, in containers, or in assembled items not otherwise classified; and certain assembled chemical items.

d. Class Division 1.4. Class 1, Division 4 includes explosives with a moderate fire hazard, but no blast hazard. They are comparable to Q-D Class 1. Items assigned to this class primarily present fire hazards producing no blast and virtually no fragmentation or toxic hazards beyond the normal fire hazard (clearance) distance. Examples of such items: Small arms ammunition without explosive projectiles; fuse lighters; certain squibs; distress signals; 20mm ammunition without explosive projectiles; colored smoke grenades, and certain valves or switches containing explosives.

Class 6 - Poisonous (Toxic) and Infectious Substances. Class 6 materials are divided into two divisions in the same manner as used for Class 1. The two divisions of Class 6 are:

a. Class Division 6.1. Poisonous (toxic) gas, vapor, or substances. These materials are comparable to Q-D class 8, which includes those CB agents and items not normally assembled with explosives components, or where explosives components present little or no blast or fragment hazards. No quantity-distances separations have been specifically established for this class as a whole. Where special safety criteria or instructions have not been provided with (or for) the stock involved and safety separation appears necessary because of agent persistency, volatility, toxicity, or other particular feature, requests for information should be made to higher headquarters.

b. Class Division 6.2. Substances containing disease-producing micro organisms. (This Class Division category is included for information only, since the Air Force does not possess Class Division 6.2 ammunition.)

Exercises (205):

If one of the following statements is correct, mark it True; if it is Flase, correct it.

_____ 1. The Department of Defense has implemented all but two (Classes 1 and 6) of the UNO classes of dangerous materials.

_____ 2. The classes of dangerous materials implemented by DOD are further subdivided into divisions based on the character and predominance of associated hazards and on the potential for causing personnel casualties or property damage.

_____ 3. Class 1, Division 1, includes explosives comparable to Q-D Class 7 and (M) designated items, which are principally a mass fire hazard and may mass detonate when a small portion is initiated by any means.

_____ 4. There is a possibility that entire stacks of some items in Class 2, 3, 4, and 6 may also mass detonate in the same manner as Class 7 explosives.

_____ 5. Non-mass-detonating, fragment producing explosives comparable to Q-D Classes 3, 4, 5, and 6 are assigned to Class 1, Division 2.

_____ 6. Class 2 quantity-distance items are assigned to Class Division 1.2.

_____ 7. Fires involving materials assigned to Class Division 1.3 usually burn vigorously with little or no possibility of extinguishing fires that have gained headway in storage situations; any explosions normally are confined to pressure ruptures of containers, and they produce propagating shock waves.

_____ 8. Class 1, Division 4 includes explosives with a moderate fire hazard and blast hazard. They are comparable to Q-D Class 1.

_____ 9. Small arms and 20mm ammunition without explosive projectiles are assigned to Class Division 1.4.

_____ 10. Class Division 6.1 assignments are made to materials comparable to Q-D Class 8.

_____ 11. Substances containing disease-producing microorganisms are given Class 6.2 assignments, which are comparable to Q-D Class 8 (M) items.

206. Match Class 1 explosive items with the explosive compatibility groups to which they belong.

Storage Compatibility Groups for Class 1 Explosives. With the many different explosives and explosive items in use today, it would be all but impossible to find space to store each type or group of explosives separately. Therefore, storage compatibility groups have been established. These storage compatibility groups take into consideration all of the various hazards of each item and rate them accordingly. You may expect to find more than one type of explosive stored behind any given fire symbol, but the most hazardous of those items stored there will determine which fire symbol is to be displayed. Familiarize yourself with the following storage compatibility groups:

Group A - Initiating Explosives. Bulk initiating explosives, which have the necessary sensitivity to heat, friction, or percussion to make them suitable for use as initiating elements in an explosive train. (The key words are "Bulk Initiating Explosives.")

Group B - Detonators and similar initiating devices. Items containing initiating explosives that are designed to initiate or continue the functioning of an explosive train.

Group C - Bulk propellants, propelling charges, and devices containing propellant with or without their means of ignition. Items that, upon initiation, will deflagrate, explode, or detonate. ("Propellant" is the key word, and liquid propellants are not included.)

Group D - Black powder, high explosives (HE), and ammunition containing HE without its own means of initiation and without propelling charge. Ammunition and explosives that can be expected to explode or detonate when any given item or component thereof is initiated. (The key words are "without its own means of initiation.")

Group E - Ammunition or devices containing HE without its own means of initiation and with propelling charge. (The key words are "HE, with propelling charge, and without its own means of initiation for the HE.")

Group F - Ammunition containing HE with its own means of initiation and with or without propelling charges. We have only one type of item in this group - grenades, both hand and rifle. (Some grenades are included in other groups.)

NOTE: As used in Groups D, E, and F, "with its own means of initiation" indicates that the ammunition has its normal initiating device assembled to it and this device is considered to present a significant risk during storage. However, the term does not apply when the initiating device is packaged so that it cannot detonate the ammunition by functioning accidentally, or when fuzed end items are so configured and packaged that they cannot be armed accidentally. The initiating device may even be assembled to the ammunition, provided its safety features preclude initiating or detonating the end item's explosive filler if the device functions accidentally. Hand grenades are considered to have their own means of initiation, as the fuze has no out-of-line component and will detonate the grenade if the fuze is initiated. 20mm HEI ammunition is considered to be without its own means of initiation, as the fuze, if initiated, will not detonate the projectile because of the out-of-line rotor.

Group G - Fireworks and illuminating, incendiary, smoke (including HC), or tear-producing munitions that are not water activated or flammable liquid or gel and do not contain white phosphorous. Ammunition that, upon functioning, results in an incendiary, illumination, lachrymation (tear gas), smoke, or sound effect.

Group H - Ammunition containing both explosives and white phosphorous or other pyrophoric material. Ammunition in this group contains fillers that are spontaneously flammable when exposed to the atmosphere.

Group J - Ammunition containing both explosives and flammable liquids or gels. Ammunition in this group contains flammable liquids or gels that are not spontaneously flammable when exposed to water or the atmosphere. (This group presently includes fire bombs without explosives.)

Group K - Ammunition containing both explosives and toxic chemical agents. Ammunition in this group contains chemicals specifically designed for incapacitating effects more severe than lachrymation. (The key words are "toxic chemical agents.")

Group L - Ammunition not included in other compatibility groups. Ammunition having characteristics that do not permit storage of other types of ammunition, or kinds of explosives, or dissimilar ammunition of this group.

Group S - Ammunition presenting no significant hazard. Two types of ammunition are included in Group S. The first type is ammunition so designed or packed that an explosion in storage is confined and self-contained within the item or package. The second type is ammunition so designed or packed that an incident may destroy all items in a single pack, but is not communicated to destroy the other packs. For either type, an external fire will not cause the near - instantaneous explosion of the total contents of the package.

The compatibility chart, table 2-1, shows how the various compatibility groups may be stored. The following notes must be used with the compatibility chart.

NOTES FOR TABLE 2-1.

1. The marking "X" at an intersection of the above chart indicates that those groups may be combined in storage. Otherwise, mixing is prohibited or restricted per Note 2 below.

2. The marking "Z" at an intersection of above chart indicates that, when warranted by operational considerations or magazine nonavailability and when safety is not sacrificed, logical mixed storage of limited quantities of some items of different groups may be approved. These relaxations involving mixed storage are to be approved by Hq USAF (IGD/SEV) and are considered deviations. Examples of acceptable combinations of Class 1 are:

a. Division 1 Group C bulk propellants with Division 1 Group D bulk HE.

b. Division 1 Group C rocket motor with Division 1 Group D bombs (HE) without their own means of initiation.

c. Group C rocket motors with Group E complete rocket systems having the same rocket motors.

d. Division 3 Group C bulk propellants or bagged propelling charges with Division 3 Group G pyrotechnics without their own means of initiation.

3. Equal numbers of separately packaged components of complete rounds of any one basic model number may be stored together or with assembled rounds made up from these components. Hq USAF (IGD/SEV) may authorize a deviation to store separately packaged components of more than one basic model number as long as the compatibility group of assembled end items is the same.

4. Group K requires not only separate storage from other groups, but may also require separate storage within the group. Hq USAF (IGD/SEV) shall determine which items under Group K may be stored together and which must be stored separately.

Exercises (206):

1. Match each of the explosive items listed in column B with its correct compatibility group in column A by writing the correct letter in the blank provided. No item may be used twice, and some items are not used.

Column A

_(1) Group A
_(2) Group B
_(3) Group C
_(4) Group D
_(5) Group E
_(6) Group F
_(7) Group G
_(8) Group H
_(9) Group J
_(10) Group K
_(11) Group L
_(12) Group S

Column B

a. Detonators and similar initiating devices.
b. Ammunition containing HE without its own means of initiation and with propelling charge.
c. Ammunition containing materials that have a radiation hazard.
d. Black powder, high explosives (HE), and ammunition containing HE without its own means of initiation and without propelling charge.
e. Ammunition presenting no significant hazard.
f. Ammunition containing both explosives and flammable liquids or gels.
g. Ammunition containing HE with its own means of initiation and with or without propelling charges.
h. Initiating explosives.
i. Ammunition containing both explosives and white phosphorous or other pyrophoric material.
j. Explosive devices that

GROUP	A	B	C	D	E	F	G	H	J	K	L	S
A	X	Z										Z
B	Z	X										X
C			X	Z	Z		Z					X
D			Z	X	X							X
E			Z	X	X							X
F						X						X
G			Z				X					X
H								X				X
J									X			X
K										Z		
L												
S	Z	X	X	X	X	X	X	X	X			X

TABLE 2-1
COMPATIBILITY CHART

Column B

contain deflagration materials and propelling charges.

k. Ammunition not included in other compatibility groups.

l. Bulk propellants, propelling charges, and devices containing propellant with or without their means of ignition.

m. Fireworks and illuminating, incendiary, smoke (including HC), or tear-producing munitions that are not water activated or flammable liquid or gel and do not contain white phosphorous.

n. Ammunition containing both explosives and toxic chemical agents.

207. Identify fire and chemical hazard symbols by their descriptions and/or the materials they denote.

Fire Symbol 1. Fire symbol 1 is octagonal in shape with a black number 1 on an orange background. The symbol is 24 inches wide, with the number being 10 inches high by 2 inches thick. Fire symbol 1 (fig. 2-1) is used to denote the presence of DOD Hazard Class/Division 1.1 explosives. These materials present primarily a blast hazard and can be expected to mass detonate when involved in a fire. Examples of materials stored under this symbol are demolition charges, blasting caps, dynamite, photoflash cartridges, warheads, bombs, shaped charges, 20mm and larger HE (high explosive) ammunition, and certain types of mines, rocket heads and motors, propellants, fuzes, and hand grenades.

Fire Symbol 2. Fire symbol 2 is cross-shaped with a black number 2 on an orange background. The

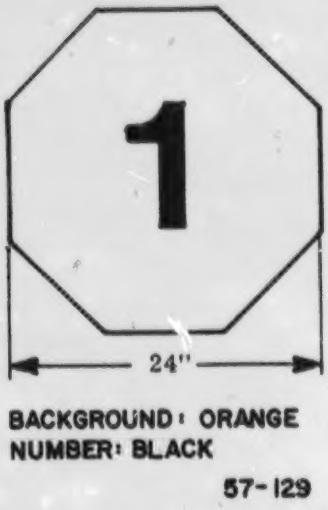
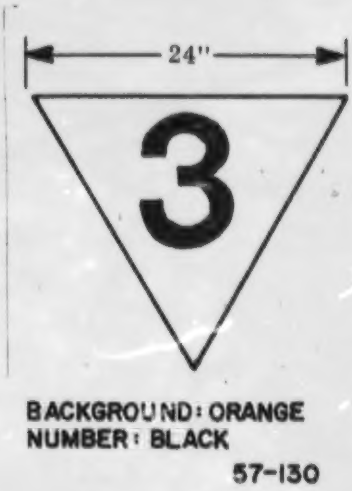


Figure 2-1. Fire symbol 1.



e 2-3. Fire symbol 3.

symbol is 24 inches long (through the arms) and 8 inches wide at each arm, with the number being 10 inches high by 2 inches thick. Fire symbol 2 (fig. 2-2) is used to denote the presence of DOD Hazard Class/Division 1.2 explosives, which present both a blast and fragment hazard. Examples of materials stored under this symbol are certain types of impulse cartridges, chemical rockets, mines, rocket motor igniters, initiators, rocket motors, fuze delay elements, and 20mm and larger ammunition.

Fire Symbol 3. Fire symbol 3 is an inverted triangle with a black number 3 on an orange background. The symbol is 24 inches long on each side; the number is 10 inches high by 2 inches thick. Fire symbol 3 (fig. 2-3) denotes the presence of DOD Hazard Class/Division 1.3 explosives, which present primarily a mass fire hazard. Examples of materials stored under this symbol are chemical and incendiary bombs and hand grenades, napalm B, smoke pots, fuzes, fire starters, catapults, extraction rockets, engine starter cartridges, and certain types of propellants.

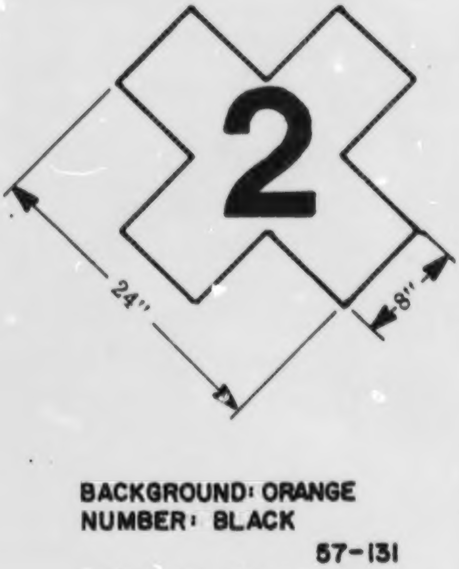
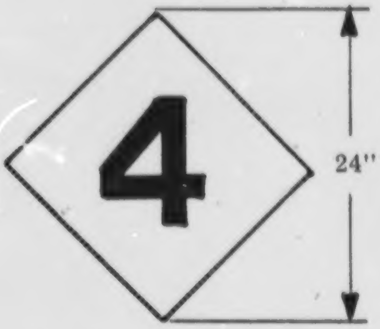


Figure 2-2. Fire symbol 2.

Fire Symbol 4. Fire symbol 4 is diamond in shape with a black number 4 on an orange background. The symbol is 24 inches from point to point (through the center); the number is 10 inches high by 2 inches thick. Fire symbol 4 (fig. 2-4) denotes the presence of DOD Hazard Class/Division 1.4 explosives, which present primarily a moderate fire hazard. Examples of materials stored under this symbol are small arms ammunition without explosive projectiles, fuze liters, certain squibs, colored smoke grenades, and certain valves or switches containing explosives.

Chemical Hazard Symbols. There are three basic chemical hazard symbols, all of which are circular in shape. These symbols denote the presence of chemical agents and identify precautions required when such material is involved in a fire. They must be placed in close proximity to the fire symbol so that each is readily visible to approaching firefighting personnel. In some instances, it may be necessary to post more than one chemical hazard symbol in addition to the fire symbol.

Full protective clothing symbol. The chemical hazard symbol illustrated in figure 2-5 requires the wearing of full protective clothing to fight fires. Each variation provides a ready means for identifying the type of chemical agents present,



COLOR

BACKGROUND : ORANGE
NUMBER : BLACK

57-128

Figure 2-4. Fire symbol 4.

together with the type of full protective clothing required (which also varies, depending on the chemical agent being stored). Variations in this symbol are identified by the color of both the rim of the symbol and the color of the figure contained in the symbol. The background color of this symbol, regardless of the variation, is BLUE.

When this symbol has a RED *rim and figure*, it denotes the presence of casualty agents that cause death by absorption, injestion, and/or inhalation. The full protective clothing required to fight fires involving such material is identified as set 1, in figure 2-5. Set 1 consists of the following:

(1) Gas mask, M9A1.
(2) Impermeable suit (coveralls, hood, gloves, fireman's boots, and boot covers).

When set 1 protective clothing is required, it MUST be worn *under* the normal bunker clothing. The M9A1 gas mask must also be used, as a self-contained breathing apparatus will NOT work with a full chemical suit. In fighting fires that require the use of set 1 full protective clothing, firefighters MUST work in teams of twos and their exposure to the agents involved *must* be limited to no more than 20 minutes. At least one backup team of two persons should also be on hand to give assistance to the firefighting team(s) if necessary. The backup team should be fully dressed and ready to go at any time while on standby.

When the symbol is colored with a YELLOW *rim and figure*, it denotes the presence of harassing agents (riot control agents and smokes). The full protective clothing it requires is identified as set 2 in figure 2-5. Set 2 consists of the following:

(1) Gas mask, M9A1.
(2) Coveralls.
(3) Protective gloves.

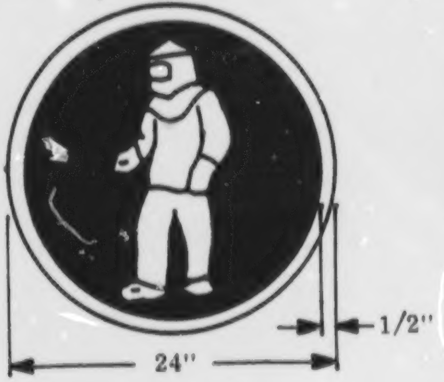
When the symbol is colored with a WHITE *rim and figure*, it denotes the presence of white phosphorous. The full protective clothing it requires is identified as set 3 in figure 2-5. Set 3 consists of the following:

(1) Flame-resistant coveralls.
(2) Flame-resistant (asbestos) gloves.
(3) Gas mask, M9A1.

Firefighting personnel equipped with normal heat-resistant clothing (bunker suit) and gas mask or self-contained breathing apparatus do not require the protective clothing identified as sets 2 and 3 when fighting fires involving material in which sets 2 and 3 are specified.

Breathing apparatus symbol. The chemical hazard symbol illustrated in figure 2-6 denotes the presence of material that requires firefighting personnel to wear breathing apparatus (gas mask or self-contained breathing apparatus). Examples of such material are signalling smokes, pyrotechnic material (PT), calcium phosphite, thermite or thermate (TH), ammonium-zinc oxide-hexachloroethane smoke (HC), and napalm (NP). The background color of this symbol is BLUE with the *rim and figure* in WHITE.

Apply no water symbol. The chemical hazard symbol illustrated in figure 2-7 denotes the presence of material for which water is NOT a suitable extinguishing agent, and must not be applied. Examples of material that require the posting of an "Apply No Water" symbol are ammonium-zinc oxide-hexachloroethane smoke (HC), thermite or thermate (TH), pyrotechnic material (PT), and

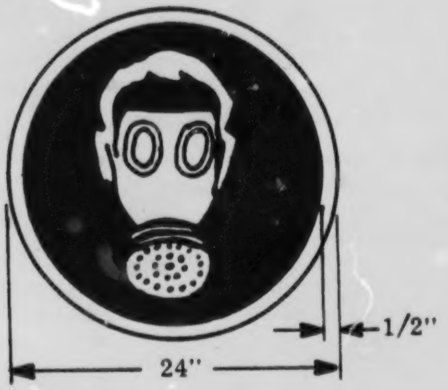


Color

The background of the symbol is blue
The figure and rim are:
Red for Set 1 Protective Clothing
Yellow for Set 2 Protective Clothing
White for Set 3 Protective Clothing

57-126

Figure 2-5. Full protective clothing symbol.



Color
The background of the symbol is blue
The figure and rim are white
57-125

Figure 2-6. Breathing apparatus symbol.

calcium phosphite. The background color of this symbol is WHITE, the *circle and diagonal stripe*, are RED, and the *figures* are BLACK.

Symbol Sizes. The size of the symbols for fire and chemical hazards are indicated in figures 2-1 through 2-7. *Half-sized symbols* may be used for application on doors and lockers *inside* buildings or hangars.

Exercises (207):
Complete the following statements.

1. In combating a fire involving demolition charges and/or dynamite, you would expect to find these items stored behind Fire Symbol ______ which is ______ in shape, with an ______ background and number in ______ .

2. A cross-shaped symbol is used to denote the presence of Class/Division ______ Explosives, which present both a ______ and ______ hazard. This symbol is known as fire symbol ______ .

3. Explosives that present primarily a mass fire hazard are stored under what fire symbol?

4. A diamond, fire symbol ______ , denotes the presence of explosives that present what kind of hazard.?

5. Explosives stored under Fire Symbol ______ present the most serious hazard, while those under Fire Symbol ______ present the least hazard; the remaining two class/divisions are stored under fire symbols which are cross-shaped and an inverted traingle, with the ______ symbol being the more hazardous of the two.

6. When you encounter a circular hazard symbol, you should be prepared to deal with what type materials?

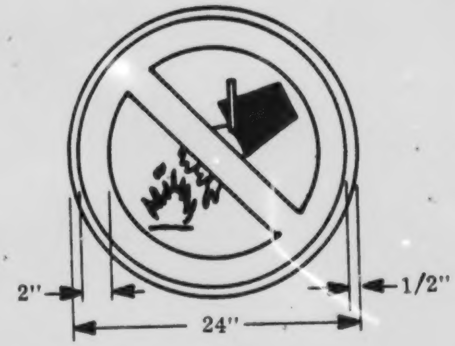
7. The hazard symbol that requires full protective clothing worn under a set of bunkers is ______ in shape with a ______ background and rim and figure in ______ .

8. Storage sites for harassing agents display a chemical hazard symbol with the rim and figure of what color?

9. How can you tell if white phosphorous is being stored in a given area?

10. Describe the symbol that denotes materials that require you to wear breathing apparatus during a fire.

11. A chemical hazard symbol that has a white background with a red circle and diagonal stripe, and figures in black will indicate what condition exists for firefighters?



Color
The background of the symbol is white
The circle and the diagonal stripe are red
The figures are black
57-127

Figure 2-7. Apply no water symbol.

12. Where may "half-sized" fire and chemical hazard symbols be used?

2-2. NBC Materials

With the advent of new and unconventional weapons, the possibilities that you and your fellow firefighters may become involved in situations of an unusual nature become even greater. More and more nuclear, biological, and chemical (NBC) materials are being produced, transported, and stored. As the types and number of these weapons increase, so do the chances of your becoming involved.

No longer are unconventional weapons restricted to a minority of aircraft and missile installations. Their storage, use, and transportation at and between Air Force installations are becoming commonplace. Their distribution and storage have become so widespread that it is imperative for all fire protection personnel to become familiar with the weapons, the associated hazards, and what must be done if they are involved in an accident.

208. Given a series of statements concerning chemical munitions, identify those statements that are correct and correct those that are invalid.

Chemical munitions are compounds and mixtures other than pyrotechnics (signaling devices) that are used as fillers in artillery shells, grenades, rockets, bombs, and pots. They are classified according to tactical use, effect, and purpose. Some of these uses are as casualty agents, for training and riot control, for smoke screens, and as incendiaries.

Casualty Agents. A casualty agent is any material that can produce a toxic physiological effect. Such materials may be in a solid, liquid, or gaseous state, both before and after dispersion. Four types or combinations of materials are used as casualty agents: blistering agents, choking gases, blood agents, and nerve agents.

Blister agents are materials that affect the nose, throat, eyes, lungs or exposed skin tissue. They produce casualties by causing inflammation, blisters, and destruction of body tissue. The principal agents in this group are mustard gas and lewisite. The major effect of mustard gas is blistering, lung irritation (if inhaled), and permanent injury of the eyes or blindness (if liquid agent gets into the eyes). Lewisite, in addition to being a blistering agent and lung irritant, acts as a poison and is highly toxic.

Choking gases affect the nose, throat, and lungs of unprotected personnel. They cause casualties by depriving people of oxygen. The principal gas in this group is phosgene. In high concentrations, one or two breaths may be fatal within a few hours. Phosgene produces only a very slight irritation in the air passages; therefore, personnel exposed to this gas are likely to inhale a large amount without being aware of the fact. Because of the lack of irritation at the time of inhalation, personnel exposed to it often have little or no warning symptoms until it is too late to avoid serious poisoning.

Blood and nerve agents, absorbed by the bloodstream, affect the nervous system, respiratory system, or muscular functions of the body, causing temporary or permanent paralysis or instant death. Nerve gases are usually colorless and their odor is faint or nonexistent. On exposure, personnel experience nausea, vomiting, and diarrhea; these effects are followed by muscular twitching and convulsions. Because of the extreme toxicity of nerve agents, their effects can be caused by extremely low concentrations of the agents. The results take place quite rapidly. Two examples of these poisons are hydrocyanic acid and cyanogen chloride.

Hydrocyanic acid is a colorless gas; its odor is quite faint, and it is not readily detected. On exposure, personnel first experience a rapid stimulation of the respiratory system. Death by paralysis of the respiratory system may occur in a few minutes. Cyanogen chloride is a colorless liquid; upon release from its container, it changes into a colorless gas that is rather heavy (twice the weight of air). On contact or exposure, this agent will irritate flesh and stimulate a strong flow of tears. Its action is rapid after inhalation, producing paralysis of the respiratory system, and death. Unlike hydrocyanic acid, it first produces an involuntary spasm of short duration in the upper respiratory tract, thus giving some warning of its presence.

Training and Riot Control Gases. A group of chemical agents known as harassment agents are used for purposes of training and riot control. Upon contact or exposure, these agents will cause partial or complete temporary disability of personnel. These materials may be used separately or in combination.

Chloracetophenone, commonly known as tear gas, is typical of this type of chemical agent. It is a solid material which, converted into a gas aerosol of finely divided particles, will cause a profuse flow of tears. In normal concentrations, this agent has no permanently injurious effect on the eyes. In high concentrations, it will irritate the skin, producing a burning and itching sensation.

Adamsite is a typical example of the vomiting gases. It is yellow or green in the solid state and is dispersed by munitions of the burning type, such as candles and grenades. Physiologically, it causes violent sneezing, intense headache, nausea, and temporary physical disability.

Screening Smokes. A screening smoke is produced by the dispersion of particles in the atmosphere by means of the burning of solids or the spraying of liquids. Smoke screens are used to obscure military movements as well as to spot artillery fire and bomb strikes. The principal smoke-producing agents are white phosphorous (WP), sulfur trioxide-chlorsulfonic mixtures (FS), and hexachloroethane-zinc mixture (HC).

White phosphorous is a white-to-light-yellow, waxlike, luminous substance which, on ignition, produces a yellow-white flame and dense white smoke. WP smoke is unpleasant to breathe but harmless; however, the solid WP is poisonous if taken internally. Used in ammunition in small particles, it ignites spontaneously on contact with the air and will continue to burn on such contact even when embedded in human flesh. White phosphorus is used in artillery and mortar shells, grenades, rockets, and bombs. It also is used as an igniter for incendiary ammunition containing flammable fuels.

Sulfur trioxide-chlorsulfonic acid mixture is a liquid with an acrid and acid odor; it produces dense white smoke when dispersed in a humid atmoshere. FS smoke is nonpoisonous; however, the liquid will irritate and inflame the skin upon contact. FS is dispersed by mortar shells, grenades, and spray from cylinders placed in aircraft.

Hexachloroethane-zinc mixture is a combination of zinc powder, hexachloroethane, ammonium perchlorate, and ammonium chloride. It is normally in the solid state. When it ignites, it produces zinc chloride that passes into the air as a dense, grayish-white smoke. HC smoke is not toxic to unprotected personnel in light concentrations for short periods of time. HC is dispersed effectively from smoke pots, mortar shells, and grenades.

Incendiaries. The purpose of incendiary munitions is to start and intensify fires and to harass and cause casualties to personnel. The principal incendiary materials are thermite and thermate (TH), magnesium, incendiary oil (IM) and napalm (NP).

Thermite is a uniform mixture of powdered aluminum and iron oxide. On ignition, it produces intense heat (approximately 4300° F.) and forms a white-hot mass of molten iron and slag. Thermite is used in cartridges, bombs, grenades, and shells. Thermite as a filler is used in thin-shelled magnesium containers to form the most common type of incendiary bomb.

Thermate is basically a thermite, barium, nitrate, sulfur, and lubricating-oil composition. It is normally used in a heavy-walled container, usually made of magnesium or a magnesium alloy. Ignited, the thermate and container burn with an intense heat of about 3700° F.

Magnesium, used in fine powder, ribbon, or solid form, also burns with intense heat. It is used extensively in pyrotechnics and incendiary munitions. As a container body for thermite and thermate, it is a very effective incendiary.

Incendiary oil is an 88 percent gasoline mixture thickened with fatty soaps, acids, and special chemicals. It may also contain metallic sodium or white phosphorus for ignition. Dispersed and ignited, IM sticks to the surface of materials and continues to burn. IM burns with the characteristics and temperature of ordinary gasoline, and is used as a filler in bombs and grenades, and as a fuel for flamethrowers.

Napalm is a mixture of aviation gasoline, a jellying agent, and chemical additives. As a filler, NP may contain metallic sodium or white phosphorus for ignition. It may be used in incendiary munitions in the same manner as IM.

Exercises (208):

If one of the following statements is correct, mark it True; if it is False correct it.

_____ 1. Chemical munitions are classified according to tactical use, effect, and method of application.

_____ 2. A casualty agent may be in a solid, liquid, or gaseous state, both before and after dispersion.

_____ 3. Choking gases affect the nose, throat, eyes, lungs, or exposed skin tissue.

_____ 4. The principal blister agent is phosgene.

_____ 5. When blood and nerve agents are absorbed by the bloodstream, they may cause temporary or permanent paralysis or instant death.

_____ 6. Exposed to hydrocyanic acid, an individual will first experience an involuntary spasm of short duration in the upper respiratory tract, thus giving some warning of its presence.

_____ 7. Contact or exposure to training and riot control gases will cause partial or complete temporary disability of personnel.

_____ 8. Violent sneezing, intense headache, nausea, and temporary disability may result from exposure to or contact with adamsite.

_____ 9. Solid white phosphorus is harmless if taken internally, but WP smoke is poisonous to breathe.

_____ 10. Hexachloroethane-zinc (HC) smoke, dispersed from grenades is not toxic to unprotected personnel in light concentrations for short periods of time.

_____ 11. Thermite and thermate are two of the principal incendiary materials used.

_____ 12. When it is used as a filler, napalm may contain fine powder magnesium for ignition.

209. Given a series of statements concerning nuclear weapons, identify those statements which are correct. If a statement is invalid, correct it.

Nuclear Weapons. To perform your job as a member of a fire protection organization, you need not be concerned with how a nuclear weapon is made or how it works. But you do need to be familiar with the identification of, and the hazards created by, nuclear weapons as they affect your job. As you are well aware, much of the detailed information about nuclear weapons is classified and cannot be discussed here. This section will, therefore, contain only general information. Detailed and classified information on the particular weapon(s) you might encounter on your own base can be obtained locally on a need-to-know basis.

Rather than an attack by an enemy force using nuclear weapons, the type of situation that will most likely bring you in contact with these weapons and their components will be an accident involving aircraft armed with nuclear weapons; an accident involving a truck, train, or aircraft transporting a nuclear weapon; or a fire in an area where these weapons are stored. Since your main concern as a firefighter will be about accidents involving nuclear weapons, the danger of major and widespread nuclear radiation created by nuclear detonation will not be a hazard you will have to combat.

Characteristics. In general, nuclear bombs resemble conventional bombs in that they are inclosed in a casing that is cylindrical in shape and has tail fins. Used as the warhead on a rocket or missile, they closely resemble conventional explosive warheads. A nuclear weapon casing varies in thickness and is subject to rupture upon impact. All nuclear weapons contain an amount of nuclear material and a conventional type of high explosive (HE) that may detonate upon moderate to severe impact or when subjected to fire. The quantity of high explosives involved in a detonation may vary from a small amount to several thousand pounds. The quantity is the major hazard in such an incident. If the casing breaks open upon impact, some radiological hazard may exist.

The length of time available to safely fight a fire involving nuclear weapons depends largely upon the physical characteristics of the weapon case, the type and the amount of conventional HE involved, the intensity of the fire, and the proximity of the fire. Since weapon casings vary in thickness, the length of time (known as the time factor) that firefighters can safely combat a fire involving a nuclear weapon ranges from zero time to an indefinite period if the fire/impact incident does not detonate the high explosives immediately. The important factor in fighting this type of fire is the time factor for each type of nuclear weapon. As soon as fire envelops the weapons area of a ground vehicle, aircraft fuselage compartment, bomb bay, or wing section where external weapons may be carried, these time factors become effective.

Detonation and breakup of nuclear weapons due to impact depends to a large degree upon the characteristics of the weapon case, the impact velocity, and the location of the weapon on the aircraft; or, in the case of ground transportation, the security devices and their resistance to impact shock. If the weapon has been ruptured by an impact, so that the high explosives are exposed and involved in fire, there is very little danger of HE detonation while this material is burning.

Associated hazards. The hazards created for firefighters by nuclear weapons becoming involved in a fire or accident are quite varied but can basically be put into two categories: radiological and explosive. Of the two associated hazards, the explosion of HE in the weapon could cause the greater danger to the firefighter.

Even though nuclear weapons are designed to prevent a nuclear detonation in the event of being involved in an accident or fire, there is still a high probability that the conventional HE surrounding the nuclear material will explode. This detonation may range from a very small one to one of considerable magnitude. The breakup of the weapon due to impact or explosion may scatter pieces of high explosives. The radius of HE blast varies, depending upon the type of weapon involved and the amount of high-explosive material that actually detonates. High-explosive blast and the danger of fragmentation from these weapons may range up to 1200 feet or more. Personnel within this area could be seriously injured by either the blast or the fragmentation. You must consider the dimensions of this danger area in planning for evacuation after a weapon has been enveloped in fire for a period of time approaching or exceeding the time factor limitations.

Sometimes the HE from a nuclear weapon will melt and flow out of the weapon without burning and then become solid again upon cooling. This residue, together with the remaining high explosives, is very unstable and may readily detonate if stepped on, driven over, or disturbed in any manner. So, if it can at all be avoided, this undetonated HE and residue should never be handled by firefighting personnel.

Detonation of the HE in a nuclear weapon caused by fire or impact is likely to cause the detonation of any other weapon or HE within a radius of 300 feet of the original explosion. This is known as sympathetic detonation. This condition could cause pieces of scattered HE far removed from the actual explosion, and even from the fire area, to detonate.

There is one more hazard created by the HE in a nuclear weapon of which you should be aware. This is the hazard created by burning HE. Some types of HE that are used in nuclear weapons burn and give off toxic vapors. These vapors can cause very serious effects if they are inhaled in any large quantities.

The radioactive components within a nuclear weapon are completely inclosed by the high explosive. As long as the weapon is intact, little or no radiological hazard exists. It is only when the weapon is broken open by impact or explosion that the radioactive material becomes of concern to the firefighter.

While it is not possible to predict the exact effects of an accident involving nuclear weapons, it is safe to say that the possibility of a nuclear detonation is so remote as to be almost negligible. This means that even though the HE in a nuclear weapon may detonate, the nuclear material will not make any significant contribution to the explosion. Alpha radiation and, possibly, limited amounts of beta and gamma radiation may be present to cause a radiological hazard.

Alpha contamination (the major radiation hazard in an accident involving a nuclear weapon) of significance should not be expected to extend more than 500 feet from the site of an accident or fire involving a nuclear weapon except in the downwind direction. It may then extend as far as one-fourth of a mile. Beta and gamma radiation levels high enough to be of danger to fire protection operations and personnel will be in very close proximity to the weapon itself.

In the event the nuclear materials in the weapon are involved in fire, the smoke from the fire may contain oxidized particles of alpha-radiation-emitting materials (oxides and plutonium and uranium) in high concentration. When these small alpha particles are suspended in air, it is possible to inhale them and thus cause a deposit of plutonium or uranium on the lungs. For this reason, the number of personnel permitted to enter the vicinity of an incident involving a nuclear weapon should be kept at a minimum.

Most of the radiation that you might encounter at an accident or fire involving nuclear weapons will be alpha, and this is not a hazard if it is kept outside the body. Alpha particles have a very short range and lack the ability to penetrate the skin; so once the particles have settled to the ground, the hazard from them is greatly reduced. This is another reason that the number of persons entering the area around the explosion of a nuclear weapon should be kept at a minimum, since the movement of personnel and equipment will disturb the surface and may lift the alpha particles into the air, thus increasing the radiation hazards.

Exercises (209):

If one of the following statements is correct mark it True; if it is False, correct it.

____ 1. In the event of an accident involving nuclear weapons, the dangers of major and widespread nuclear radiation created by nuclear detonation will be a hazard which you will have to combat.

____ 2. All nuclear weapons contain a conventional type of high explosive which may detonate upon moderate to severe impact or when subjected to fire.

____ 3. The quantity of high explosives involved in a detonation of a nuclear weapon, due to an accident, is the major hazard in such an incident.

____ 4. If the fire/impact incident does not detonate the high explosives immediately, the length of time that firefighters can safely combat a fire involving a nuclear weapon ranges from zero time to one-half hour.

____ 5. The time factors for nuclear weapons become effective as soon as the weapons area of a ground vehicle, aircraft fuselage, bomb bay, or wing section where external weapons may be carried are involved in an accident/incident.

____ 6. If the weapon case of a nuclear weapon has been ruptured by an impact so that the high explosives are exposed and involved in fire, there is a great danger

3c

of HE detonation while this material is burning.

____ 7. The residue from burned high explosive is very unstable but will not detonate if stepped on or driven over.

____ 8. Sympathetic detonation is the detonation of radioactive material within a nuclear weapon or any other weapon within a radius of 300 feet of the original explosion.

____ 9. If a nuclear weapon survives an accident with no physical damage, little or no radiological hazard will exist.

____ 10. The major radiation hazard (beta combination) in an accident involving a nuclear weapon – which would be of significance – should not be expected to extend more than 500 feet from the site of the accident except in the downwind direction.

____ 11. Alpha radiation is not a hazard if kept outside the body; these particles have a very short range and lack the ability to penetrate the skin.

210. Explain what biological agents are, how they are identified, and the hazards associated with them.

Biological Agents. As the number and types of unconventional weapons increase, so do your chances of becoming involved with them in the performance of your duties as a firefighter. Although biological agents are not as widely distributed nor as commonplace as the chemical munitions discussed in the preceding paragraphs, they do exist.

Since munitions containing biological agents may be transported from base to base, it is possible that an aircraft carrying these materials may plan to stop at your base enroute to its final destination. If one of these aircraft were to crash on or near your base, your department would then become involved with biological munitions and/or agents. You can, therefore, see that an understanding of the agents used in biological munitions is important to all fire protection personnel.

Biological agents, when considered as a filler for munitions, are classified as one of three general types:

(1) Living agents (bacteria, viruses, fungi).

(2) Toxins (poisonous byproducts of living animals and plants).

(3) Chemical substances (plant growth regulators and defoliators).

As you can see, there is nothing strange about biological agents. The types of agents used are familiar to everyone. If you have ever been sick with a cold or with the flu, it was due to a simple virus infection. Have you ever suffered from athletics foot? If so, you have suffered a fungus infection. The sicknesses caused by bacteria (germs) are so numerous that almost everyone has been involved with them at some time or another. Some very common examples of the effects of toxins with which you are undoubtedly familiar are snakebites, bee stings, and food poisoning – poisonous byproducts of living animals; and poison ivy and poison oak – poisonous byproducts of living plants. When you spray your lawn to get rid of crab grass or other unwanted weeds and when a farmer treats his fields for the same purpose, plant growth regulators and chemical defoilators are being used.

Identification. Biological munitions are classified according to type and use. Under type, as you have already learned, are living agents, toxins, and chemical substances. According to use or desired effect, biological agents are classified as antipersonnel, antianimal, and anticrop.

Biological munitions and agents have a color and letter code all their own. The color is used to designate the use of the weapon (antipersonnel, animal, or anticrop), and the letter code is used to designate the filler, which consists of the specific agent. The size and construction of biological munitions are quite similar to chemical munitions. It is necessary to use color and letter codes for visual identification. Since the specific coding is classified, we will say no more on this subject.

The actual biological agents are contained in small packages, cluster form, within the munition case. In the event of an accident involving these agents, it is highly improbable that the small packages will be broken open. If you or any of your personnel find a biological munitions packet that is broken open, take the same precautions as with broken nuclear weapons – that is, leave them alone, post a guard to preserve security and to keep personnel away, and wait for qualified personnel to recover the weapon. It is possible that you might encounter biological agents in an aerosol spray container. If so, these containers will look similar to an external fuel tank and will be marked with the appropriate biological color and letter coding.

Hazards. When munitions containing biological agents are involved in an aircraft or storage fire incident, they present various degrees of hazards to the firefighter. It would be impractical to attempt to list a set of rules governing the hazards that each munition will present in any situation. These are diseases that have faced mankind for a long time. Natural and acquired immunity of each person to each disease that might be encountered must be taken into account. General health and physical condition will affect the degree of hazard created for each person. Wind and weather conditions control to a large degree the area that will be contaminated. In addition, much of the information about biological munitions and agents is classified, and we cannot discuss it here. For detailed information about the agents on your base and the exact hazards involved, your base medical personnel are your best source. This discussion will be limited to general or common hazards.

The very nature of biological agents that could be harmful to fire protection personnel (antipersonnel and some antianimal materials) make it very unlikely that any sizeable high-explosive hazard would exist in the munitions. The heat generated by detonating enough HE to constitute a life hazard to firefighting personnel would be more than sufficient to destroy most living agents or toxins. For this reason, very small charges of explosives (about the size or power of a blasting cap) are all that are used in biological munitions.

The major hazard of biological munitions lies in the fact that weapons may break or be blown open without any accompanying fire. They may be thrown clear of the fire area. In either instance, the biological agents could be liberated into the air.

Most biological agents that are harmful to man have an incubation period of from 2 to 7 days. In this length of time, medical personnel will be able to administer inoculations to personnel who may have been exposed.

Since particles of these agents are very light in weight, they are easily transmitted by wind currents. If you always approach fires from upwind, most of the hazards can be avoided. This action, in conjunction with protective clothing, breathing equipment, and medical aid, will provide additional protection if biological munitions and agents are involved in an accident on your base. The previous discussions concerning explosives and agents assumed that the explosives or agents were identified by name, symbol, or appearance. There is one instance in which this does not apply – during transportation. During transportation, a special system of identification by placards is used.

Exercises (210):

1. What are living biological agents?
2. Briefly define toxins, and give five examples of toxins.
3. State what the biological agents classified as chemical substances are used for.
4. How are biological munitions and agents identified?
5. What effect would wind and weather conditions have on biological agents involved in an accidental fire?
6. Why do biological munitions contain very small charges of explosives?
7. Should biological agents become involved in a fire at your base, how would you minimize the hazards of these agents to yourself while combating the fire?

2-3. Placarding

Placards are used to identify dangerous materials that are being transported. All commercial or military vehicles (to include railroad cars and aircraft) transporting dangerous materials on or off Government property are marked with placards. These placards provide a standard identification for transport-type vehicles and are not authorized for any other use.

Motor vehicles or rail cars containing dangerous materials that require a placard must have the appropriate placard on each side and end (except where two or more placarded units are connected together, then placards are not to be facing each other). A square background is required on all railcars placarded EXPLOSIVES A, POISON GAS, and POISON GAS EMPTY. This background must be 15¼ inches on each side with ½-inch black border on each side leaving a 14¼-inch white square on which the appropriate placard is affixed.

Placards for aircraft must be displayed conspicuously, covering all approach angles as a warning to taxiing aircraft, vehicular, or pedestrian traffic and for firefighting purposes. Placards may be temporarily affixed to the aircraft (to be removed before flight) or fastened to a portable stand so located and positioned that they do not create a ground or aircraft taxiing hazard.

All transportation placards must be 10¾ inches on each side (from point to point), the outer ½ inch of which must be white. (In fig. 2-8, the ½-inch border is shown by a dotted line outer border to indicate the full size of the placard. This dotted line is not a part of the placard.)

More than one placard may sometimes be required to properly identify the materials being

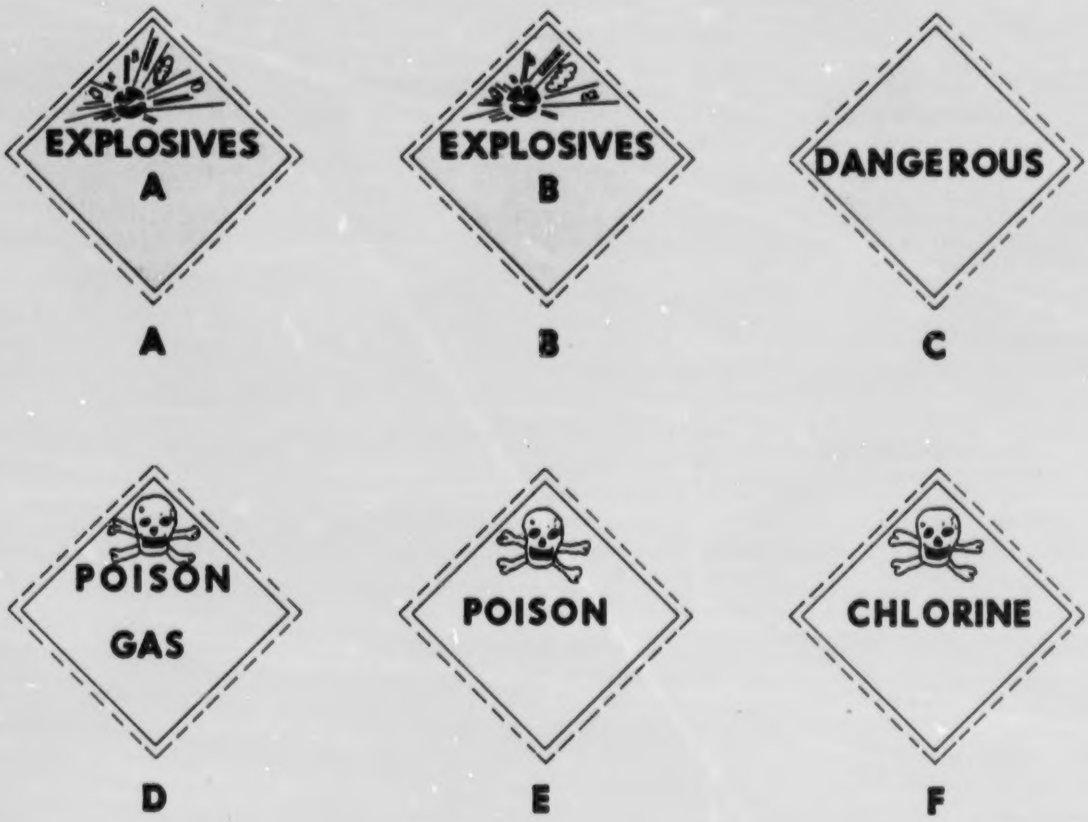


Figure 2-8. Transportation placards.

transported – such as DANGEROUS-RADIOACTIVE. In such cases, use the placards necessary to best identify the hazards. (NOTE: The definition and/or classifications given in the discussion of placards are DOT (Department of Transportation) identifications and NOT NFPA, as in Chapter 1.)

211. Match the placard titles with their descriptions and with materials they identify.

EXPLOSIVES A. The EXPLOSIVES A placard (fig. 2-8,A) denotes explosive material with a primary hazard, or a maximum hazard, of detonating. Treat fires involving these materials as comparable to Class 1, Division 1.

The placard must be orange with the symbol and letters in black. The word "EXPLOSIVES" must be across the center of the placard with the letter "A" centered below the word "EXPLOSIVES." The letters must be 1⅞ inches high made with a 5/16-inch stroke.

EXPLOSIVES B. The EXPLOSIVES B placard (fig. 2-8,B) denotes explosive material that presents a flammable hazard. These explosives, in general, function by rapid combustion rather than detonation.

Except for the letter "B," the EXPLOSIVES B placard specifications are the same as those for the EXPLOSIVES A placard. The location, height and stroke for the letter "B" are the same as those for the letter "A."

DANGEROUS. The DANGEROUS placard (fig. 2-8,C) may be used in place of separate placards when a total gross weight of 1,000 pounds, or more, of any two or more hazardous materials that normally require placarding is loaded on the same carrier. The DANGEROUS placard must not be used if one or more of the materials would require one of the following placards: EXPLOSIVES A,

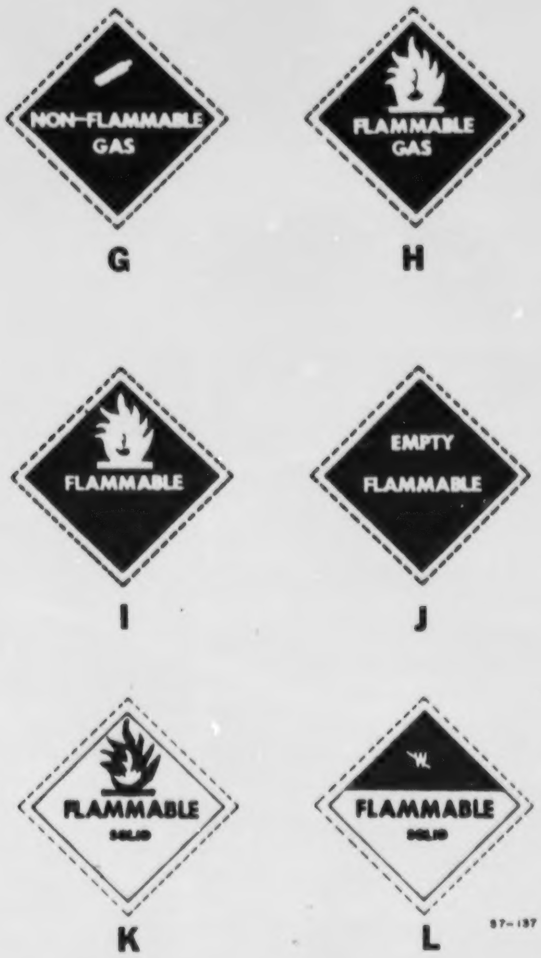


Figure 2-8b. (Cont'd.)

EXPLOSIVES B, POISON GAS, FLAMMABLE SOLID W, RADIOACTIVE, and RADIOACTIVE AND CORROSIVE.

The word "DANGEROUS" must be across the center of the placard and made with letters 2 7/32-inch high with a ⅜-inch stroke. Centered across the placard is a white section 5 inches wide. The two ends of the white area must have a ⅛-inch, red, solid line border to indicate the outer ½-inch white border. The upper and lower triangles must be red with the letters in black.

POISON GAS. The POISON GAS placard (fig. 2-8,D) denotes Class A poison. Class A poison is any poisonous gas or liquid of such nature that a very small amount of the gas or vapor of the liquid mixed with air is dangerous to life.

The word "POISON" must be across the center area of the placard with the word "GAS" centered beneath the word "POISON." The letters in both words must be 2 3/16 inches high and made with a 13/32-inch stroke. The symbol must be 3 ¼ inches high and 4 5/16 inches across the widest extremities. A ⅛-inch black border must be ½ inch from the placard edge. The background of the placard must be white with letters and symbol in black.

POISON. The POISON placard (fig. 2-8,E) denotes Class B poison. Class B poison is any liquid or solid (including pastes and semisolids) that is not a Class A poison or irritating material, but is so toxic to man as to afford a health hazard during transport.

The word "POISON" must be centered on the placard horizontal center line in letters 3 1/16 inches high and made with a 9/16-inch stroke. The symbol must be 3 11/16 inches high and 4 15/16 inches across the widest extremities. The other requirements for the placard are the same as for the POISON GAS placard.

CHLORINE. The CHLORINE placard (fig. 2-8,F) denotes chlorine, which is a poisonous gas that is highly irritating to the respiratory organs. Chlorine is used chiefly as a bleach, a disinfectant in water purification, and as an oxidizer.

The specifications for the CHLORINE placard are the same as for the "POISON GAS" and "POISON" placards except for the word "CHLORINE" and the symbol. The word "CHLORINE" must be made in letters 2 ½ inches high and with a stroke of 7/16 inch. The symbol must be 3 11/16 inches high and 5⅛ inches across the widest extremities.

NONFLAMMABLE GAS. The NONFLAMMABLE GAS placard (fig. 2-8,G) denotes a gas that is not easily ignited and does not burn rapidly if ignited. The word "NONFLAMMABLE" must be across the center area with the word "GAS" centered beneath it. The letters in both words must be 1 9/16 inches high made with a 5/16-inch stroke. The symbol must be 3 9/16 inches long with the lower portion of the cylinder being 17/32-inch wide with the neck ¼ inch wide. The placard color is green with the symbol, inscription, and border in white.

FLAMMABLE GAS. The FLAMMABLE GAS placard (fig. 2-8,H) denotes any flammable compressed gas, if either 13 percent or less (by volume) with air forms a flammable mixture or the flammable range with air is wider than 12 percent regardless of the lower limit.

The FLAMMABLE GAS placard must be red with the symbol, inscription, and border in white. The word "FLAMMABLE" must be across the placard center area with the word "GAS" centered beneath it. The letters in both words must be 2 inches high and made with a ⅜-inch stroke. The symbol bar must be 5/32-inch wide and 3 5/16 inches long. The symbol must be 4 17/32 inches high and 3 5/16 inches wide.

FLAMMABLE. The FLAMMABLE placard (fig. 2-8,I) denotes flammable liquids with a flashpoint below 100° F. The FLAMMABLE placard must be

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red with white symbol, inscription, and border. The word "FLAMMABLE" must be centered on the placard horizontal center line with the letters being 2 inches high and made with an 11/32-inch stroke. The symbol must be 4 9/16 inches wide and 3 5/16 inches high with a ⅛-inch wide, 3 5/16 inches long bar beneath the symbol. The word "GASOLINE" may be used in place of the word "FLAMMABLE" if the placard is displayed on a cargo tank or portable tank being used to transport gasoline by highway. The word "GASOLINE" must be in letters of the same size and color as those in the word "FLAMMABLE."

FLAMMABLE-EMPTY. The FLAMMABLE-EMPTY placard (fig. 2-8,J) indicates that certain hazardous material has been removed from the transport vehicles and/or containers but that a hazard may still exist from residue, etc.

The specifications for the FLAMMABLE-EMPTY placard are representative of the requirements for the other EMPTY placards: NONFLAMMABLE GAS; POISON GAS; CHLORINE; OXYGEN; FLAMMABLE GAS; FLAMMABLE; COMBUSTIBLE; OXIDIZER; ORGANIC PEROXIDE; POISON; and CORROSIVE. Each EMPTY placard must be the same as the regular placard except for the top triangle. The top triangle must be black with the letters in white. The letters in the word "EMPTY" must be 1 inch high and made with a 7/32-inch stroke.

FLAMMABLE SOLID. The FLAMMABLE SOLID placard (fig. 2-8,K) denotes any solid material that is not classed as an explosive but is liable, under conditions of transportation, to cause fires through friction, retained heat from manufacturing or processing, or to be ignited readily and burn vigorously and persistently enough to create a serious transport hazard.

The word "FLAMMABLE" must be across the center of the placard with the word "SOLID" centered beneath it. The letters in the word "FLAMMABLE" must be 2 inches high and made with a ⅜-inch stroke, while the letters in the word "SOLID" must be 1½ inches high and made with a ¼-inch stroke. The symbol is of the same size as used for the FLAMMABLE placard. There must be seven red stripes and six white stripes on the placard. The red stripes must be 1 3/16 inches wide, and the white stripes 1 7/32 inches wide. The symbol and inscription must be black.

FLAMMABLE SOLID W. The FLAMMABLE SOLID W placard (fig. 2-8,L) indicates the presence of flammable solid material which is dangerous when wet.

The specifications for the FLAMMABLE SOLID W placard are the same as for the FLAMMABLE SOLID placard except for the top triangle. The top triangle must be blue with the symbol in white. The symbol must be 2¼ inches high; 2¾ inches across the top; 1¾ inches across the base, and made with a 5/16 inch stroke. The white stripe in the symbol must be 7/32-inch wide and 3½ inches long, slanting upward from right to left at an angle of approximately 21° from the horizontal.

COMBUSTIBLE. The COMBUSTIBLE placard (fig. 2-8,M) denotes combustible liquids which have a flashpoint at or above 100° F. and below 200° F. The specifications for the COMBUSTIBLE placard are the same as those for the FLAMMABLE placard except that the letters in the word "COMBUSTIBLE" must be 1⅞ inches high and made with 11/32-inch stroke. The words "FUEL OIL" may replace the word "COMBUSTIBLE" on a cargo tank or portable tank used for highway transport of fuel oil that is not classed as a flammable liquid. The words "FUEL OIL" [illegible] be in letters of the same size and color as th[illegible] the word "COMBUSTIBLE."

OXIDIZER. The OXIDIZER placard (fig. 2-8,N) denotes a substance that yields oxygen readily to stimulate the combustion of organic matter. The word "OXIDIZER" must be centered on the placard horizontal center line in letters 2½ inches high made with a 15/32-inch stroke. The placard must be yellow with the letters and symbol in black. The overall height of the symbol must be 4 5/16 inches with the bar measuring ⅛ inch wide and 2 3/16 inches long. The symbol must be 2⅜ inches across the widest part.

OXYGEN. The OXYGEN placard (fig. 2-8,O) identifies liquefied, pressurized oxygen contained so that it does not meet the requirements of being a compressed gas. The specifications for the OXYGEN placard are the same as those for the OXIDIZER placard except that the letters must be made with a 7/16-inch stroke.

ORGANIC PEROXIDE. The ORGANIC PEROXIDE placard (fig. 2-8,P) identifies derivatives of hydrogen peroxide where one or more of the hydrogen atoms have been replaced by organic radicals. The word "ORGANIC" must be across the center line of the placard with the word "PEROXIDE" centered beneath the word "ORGANIC." The letters in both words must be 2 inches high and made with an 11/32-inch stroke. The symbol must be 3 11/16 inches high and 2 1/16 inches wide with the bar 3/16-inch wide and 1⅞ inches long. The placard must be yellow with the symbol and inscription in black.

CORROSIVE. The CORROSIVE placard (fig. 2-8,Q) identifies a liquid or solid that causes visible destruction or irreversible alterations in human skin tissue at the site of contact or, in the case of leakage from its packaging, a liquid that has a severe corrosion rate on steel.

The word "CORROSIVE" must be across the center of the placard and made with letters 2 1/16 inches high with an 11/32-inch stroke. The base of the top, white triangle must be 1½ inches above the

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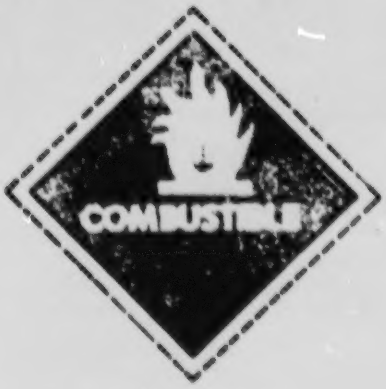
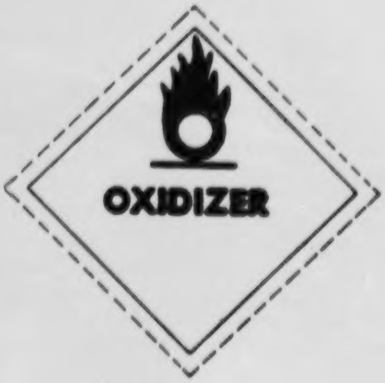

COMBUSTIBLE

M



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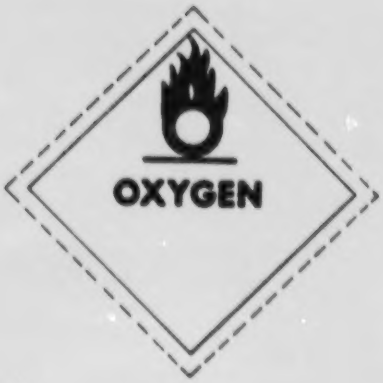

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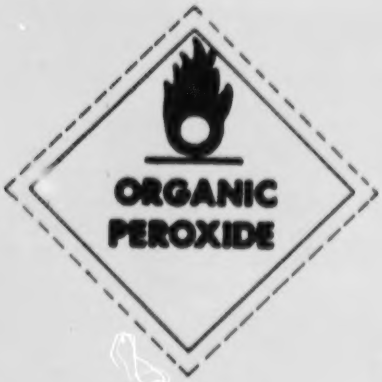
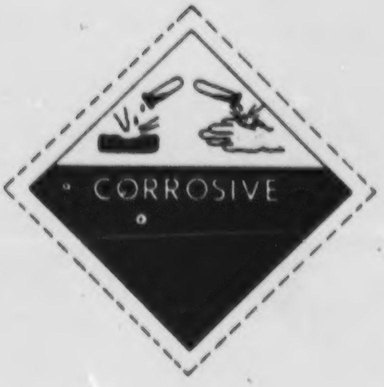
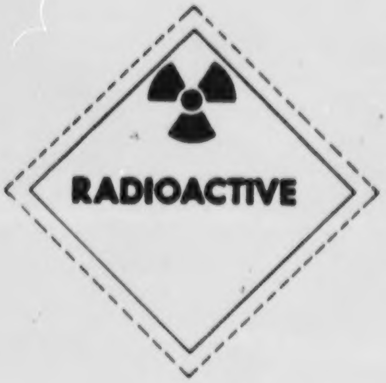

ORGANIC
PEROXIDE

P



Q


RADIOACTIVE

R

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Figure 2-8c. (Cont'd.)

placard horizontal center line. The lowest part of the symbol must be 1⅝ inches above the placard horizontal center line. The height of the symbol measured from a horizontal line extended from the lowest part of the symbol must be 3¼ inches, and the width across the widest part must be 7⅜ inches. The upper white area must have a ⅛-inch black solid line border as an extension from the edge of the black area to indicate the outer ½-inch white placard border. The CORROSIVE placard must have the center and lower area black except for the letters in the word "CORROSIVE", which must be white. The symbol must be black and white.

RADIOACTIVE. The RADIOACTIVE placard (fig. 2-8,R) identifies full-load shipments of radioactive material, or less than full-load shipments of radioactive material which are controlled (by special arrangements between the shipper and carrier) to provide nuclear criticality safety in transportation.

The word "RADIOACTIVE" must be centered on the placard horizontal center line in letters 2 inches high with an 11/32-inch stroke. The lower edge of the yellow triangle must be 1⅛ inches above the placard horizontal center line with the lower edge of the symbol ⅛ inch above the lower edge of the yellow triangle. The symbol must have an overall height of 4½ inches. The lower white area must have a ⅛ inch black solid line border extended from the edge of the yellow area to indicate the outer ½ inch white placard border. The RADIOACTIVE placard must have the top portion yellow with the symbol black. The lower portion must be white and the inscription black.

Exercises (211):

1. Match each of the placard descriptions listed in column A with the correct placard title listed in column B by writing the correct letter or letters in the blank provided. Each title may be used once, more than once, or not at all.

Column A

_(1) The placard is orange with the symbol and letters in black.
_(2) The symbol on the placard is a skull and crossbones.
_(3) The placard has a center section of white with the top and bottom triangles of red.
_(4) The placard is white with the symbol and letters in black.
_(5) The top portion of the placard is yellow while the lower portion is white. Both portions have letters or symbols in black.
_(6) The placard has alternating red and white stripes, the symbol and letters are black.
_(7) The top triangle of the placard is blue with the symbol in white.
_(8) The placard is yellow with the symbol and letters in black.
_(9) The top triangle of the placard is black with the letters in white.
_(10) The upper area of the placard is white while the center and lower area is black except for the inscription, which is white. The symbol is black and white.
_(11) The placard is red with the symbol and letters in white.
_(12) The placard is green with the letters and symbol in white.

Column B

a. RADIOACTIVE
b. NONFLAMMABLE GAS
c. CORROSIVE
d. EXPLOSIVES C
e. COMBUSTIBLE
f. EXPLOSIVES A
g. OXIDIZER
h. OXYGEN
i. POISON GAS
j. FLAMMABLE GAS
k. EMPTY
l. DANGEROUS
m. CHLORINE
n. POISON
o. FLAMMABLE SOLID W
p. EXPLOSIVES B
q. FLAMMABLE SOLID
r. IRRITANT
s. FLAMMABLE
t. ORGANIC PEROXIDE

2. Match each of the hazardous materials listed in column A with the correct placard title listed in column B by writing the correct letter in the blank provided. No title may be used twice, and some titles are not used.

Column A

_(1) The material is a gas or liquid of such a nature that a very small amount of the gas or vapor of the liquid mixed with air is dangerous to life.
_(2) These materials are comparable to Class Division 1.1 items.
_(3) The material is a gas that is not easily ignited and does not burn rapidly if ignited.
_(4) In some cases, special arrangements must be made between the shipper and carrier to provide nuclear criticality safety when these materials are transported.
_(5) This material is highly irritating to

Column B

a. EXPLOSIVES A
b. EXPLOSIVES B
c. DANGEROUS
d. POISON GAS
e. POISON
f. CHLORINE
g. NONFLAMMABLE GAS
h. FLAMMABLE GAS
i. FLAMMABLE
j. FLAMMABLE-EMPTY
k. COMBUSTIBLE
l. OXIDIZER
m. FLAMMABLE SOLID
n. FLAMMABLE SOLID W
o. CORROSIVE
p. RADIOACTIVE.
q. OXYGEN
r. ORGANIC PEROXIDE

Column A

the respiratory organs and is sometimes used as a bleach.

_(6) The words "FUEL OIL" may be used on this placard if the fuel oil is being transported by highway and is not classed as a flammable liquid.

_(7) When these materials come in contact with human skin, they cause visible destruction or irreversible alterations to the skin.

_(8) These materials are dangerous when wet.

_(9) These materials yield oxygen readily to stimulate the combustion of organic matter.

_(10) These materials generally function by rapid combustion rather than detonation.

2-4. Decontamination

Because the mission of the fire department is to save life and property, an essential part of that mission is disaster control and decontamination. To be prepared to cope with such incidents, it is necessary to develop and perfect plans through practice exercises. These plans are developed much in the same manner as prefire plans; however, the plans are made at base level and encompass the responsibilities of all participating organizations. The part the fire department plays, although a major part in many cases, is still only a part of the whole plan. The fire department, as you know, has at its control men, vehicles, communication facilities, and materials ready to respond at any time. Any or all of the personnel and material might be required to gain control of a situation before it becomes a disaster or to reduce the hazards to life and property after the incident becomes a disaster.

212. State procedures for and identify materials and equipment used in decontamination

Monitoring. Monitoring the area of the accident after a fire and/or explosion, as well as handling the weapons and component parts of the weapons, is the responsibility of predesignated specialized recovery personnel. This is not normally the duty of the fire department. Of course, you must wear protective clothing and breathing apparatus during firefighting operations to provide maximum protection from any chemical or minor radiological hazards that may be present. All exposed clothing, apparatus, and equipment used during a fire or other incident where nuclear weapons or components have been involved should be checked for possible radiological contamination by the specialized recovery personnel.

When the firefighting part of the operation is completed, all personnel and vehicles are required to go through the checkpoint set up by the disaster control command post. Here the special recovery team checks each man and each piece of equipment for indications of radioactive contamination. Whether it is an exercise or the real thing, you must cooperate with them. They are practicing their job of preventing you from carrying radioactive particles to anyone with whom you may come in contact; you are not being imposed upon, because this is all a part of the decontamination procedure.

Levels of Decontamination. The best decontamination procedure is the least expensive procedure that will reduce the hazardous concentration of contamination to a safe level within allowable time factors. There are three echelons of decontamination.

(1) Personnel perform first echelon decontamination on themselves and their equipment, using materials that are on hand. The decontamination at this point, although perhaps not complete, is sufficient to allow an individual to carry on his assigned mission in safety.

(2) Personnel of a composite unit, under specially trained supervisors, perform second echelon decontamination with equipment carried by the unit. The 3-gallon decontamination apparatus is the principal piece of equipment available for second echelon decontamination.

(3) Trained personnel usually perform third echelon decontamination at specially designated decontamination points. Contaminated areas or immovable objects require that decontamination equipment and personnel be transported to that location. Third echelon decontamination is very thorough and must be performed by a specially trained detail, section, or squadron.

Chemical, biological, and nuclear warfare agents have certain aspects in common: these agents may be in the air and travel with the wind; each may be inhaled and produce casualties; and each is capable of contaminating clothing, equipment, food, water, etc.

Common Natural Decontaminants. The decontamination agents also have some characteristics in common. Many of the accepted and more common agents are effective for decontaminating more than one type of chemical, biological, or nuclear agent. Some of the common decontaminants are:

a. Water. Flowing water washes chemical agents from surfaces or dilutes the chemical agent. Addition of soap or other cleansing chemicals will make water a more effective decontaminant.

b. Earth. Earth is used to seal in contamination, or as an absorbent for wiping off liquid contamination.

c. Fire. Fire destroys or vaporizes most war gases. Some combustible war gases (such as mustard gas) may be converted into relatively harmless products. Fire will also prove a very effective decontaminant for biological agents, since extreme temperatures will kill or destroy bacteria, viruses, and toxins.

There is another natural element that contributes to decontamination; it is weather. Some aspects of weather that affect contamination are:

a. Air. Aeration promotes decontamination, since high winds rapidly disperse the vapors of chemical and biological agents.

b. Temperature. High temperatures increase the evaporation of liquids to vapors and accelerate the dispersion of chemical agents.

c. Humidity and Precipitation. Presence of moisture tends to dissolve chemical agents. Rain aids decontamination by flushing and flooding. Puddles, however, may contain high concentrations of insoluable contaminants.

d. Sunlight. Bright sunlight serves as a decontaminating element, even in cold weather.

Standard decontaminants. In addition to the above factors that aid in decontamination, these are the standard chemical decontaminants that are used in first, second, and third echelon decontamination. Among the more common agents are:

(1) STB (supertropical bleach).
(2) DANC (decontaminating agent noncorrosive solution).
(3) HTB (high-test bleach).
(4) GUNK (Air Force cleaner).
(5) BAL ointment (British Anti-Lewisite).
(6) M5 ointment.
(7) Caustic soda, lye, etc.
(8) Organic solvents (gasoline, kerosene, alcohol, etc.).
(9) Washing soda (sodium carbonate).
(10) Disinfectants.

A number of decontaminating agents recommended for use, in addition to the above, are fire extinguishing agents. The vaporizing liquid type extinguishing agents, such as carbon tetrachloride, chlorobromomethane, and methyl bromide, are recommended for decontaminating chemical and biological contaminants.

When the operation is completed and each person has returned to his respective organization, a critique at command level should be made concerning what was observed; and suggestions should be made for improvement, addition, deletion, or substitution. A critique should be held by the fire department concerning its part of the operations and how its participation could be improved.

Exercises (212):

1. After an accident, an area suspected of being contaminated will be monitored by whom?

2. What items used during a firefighting operation will be monitored for possible radiological contamination?

3. What is the best decontamination procedure?

4. Match the statements concerning decontamination in column B with the proper echelon of decontamination in column A by writing the correct letter in the blank provided. Each statement may be used only once.

Column A

_(1) First echelon
_(2) Second echelon
_(3) Third echelon

Column B

a. The 3-gallon decontamination apparatus is the principal piece of equipment available.
b. Decontamination equipment and specially trained personnel must be transported to the area of operation for immovable objects.
c. This decontamination is very thorough and must be performed by a specially trained detail, section, or squadron.
d. You perform this kind of decontamination on yourself and your equipment.
e. Specially trained individuals supervise personnel performing this kind of decontamination using equipment carried by the decontamination unit.
f. This kind of decontamination, although perhaps not complete, is sufficient to allow an individual to carry out his assigned mission in safety.

5. Name three common agents that are effective for decontaminating more than one type of NBC agent?

6. How does aeration aid in decontamination?

7. When you are working in a contaminated area after a rain storm, what must you watch for and why?

8. What type of fire extinguishing agents are recommended for use as decontaminating agents?

9. Why should the fire department critique itself after a decontamination operation?

CHAPTER 3

Fire Extinguishers

A STORY COMES to us from an air base in Korea. It involves a young man and a portable fire extinguisher. It tells how these two – the man and the extinguisher – possibly saved many lives and millions of dollars.

It so happened that a refueling truck containing JP-4 was in an area with seven armed aircraft. The truck was going to refuel these aircraft so that another air mission could be completed. The driver of the refueling truck was busy preparing to transfer fuel to one of the aircraft. He did not see a fire start and spread under his vehicle.

If this fire had been allowed to continue, a more serious situation would surely have developed. The truck and perhaps all the aircraft nearby would soon have been on fire. The responding firefighters would have found an extremely dangerous situation when they arrived. Several aircraft and a refueling truck might have been on fire, live explosives and ammunitions subjected to fire, and a possibility of the fire spreading and involving even more aircraft. In addition, there would have been the life-hazard due to explosion while combating this fire. Quite an ugly picture, isn't it?

Because of the efforts of a quick-thinking and fast-acting airman, these things did not happen. He grabbed a portable fire extinguisher and rushed to the refueling truck. Quickly noting the wind direction and ground slope, he rolled under the truck and completely extinguished the fire.

To do this act as he did took a man with a lot of bravery. It also took a man who was very familiar with the extinguishers in his area. He knew exactly how to use them. Each firefighter should be able to match this airman's knowledge and skill in the use of portable fire extinguishers and handtools.

First aid is the immediate and temporary care given to an injured or sick person before or until the doctor arrives. When the term *first aid* is used to describe a piece of fire equipment, the same general meaning applies. Portable first-aid fire extinguishers are designed to be used on fires as soon as possible after they start and before the fire gets too far along. These extinguishers may be able to extinguish the fire or hold it in check until larger firefighting equipment arrives. In the following discussion, portable first-aid fire extinguishers will simply be referred to as "extinguishers."

Extinguishers are designed primarily for use by people other than firefighters. This does not mean that you shouldn't know how to use each one. Many times firefighters are able to extinguish fires with extinguishers carried on the firetrucks. Often you use the extinguishers kept in the area where the fire started. Your skill and knowledge in their use may mean the difference between using one small fire extinguisher or a big operation involving many firetrucks and dozens of people to extinguish a fire. Before we go on to learn about the individual extinguishers, we will discuss extinguisher maintenance intervals and hydrostatic testing.

3-1. Inspection of Extinguishers

Part of your job will be to inspect extinguishers. The extinguishers you inspect will vary in size and location. To start off with, most of your extinguisher inspections will be limited to those carried on your vehicles. As you progress, you may inspect some extinguishers located in various buildings and larger units located on the flight line. Our discussion will be limited to the smaller extinguishers.

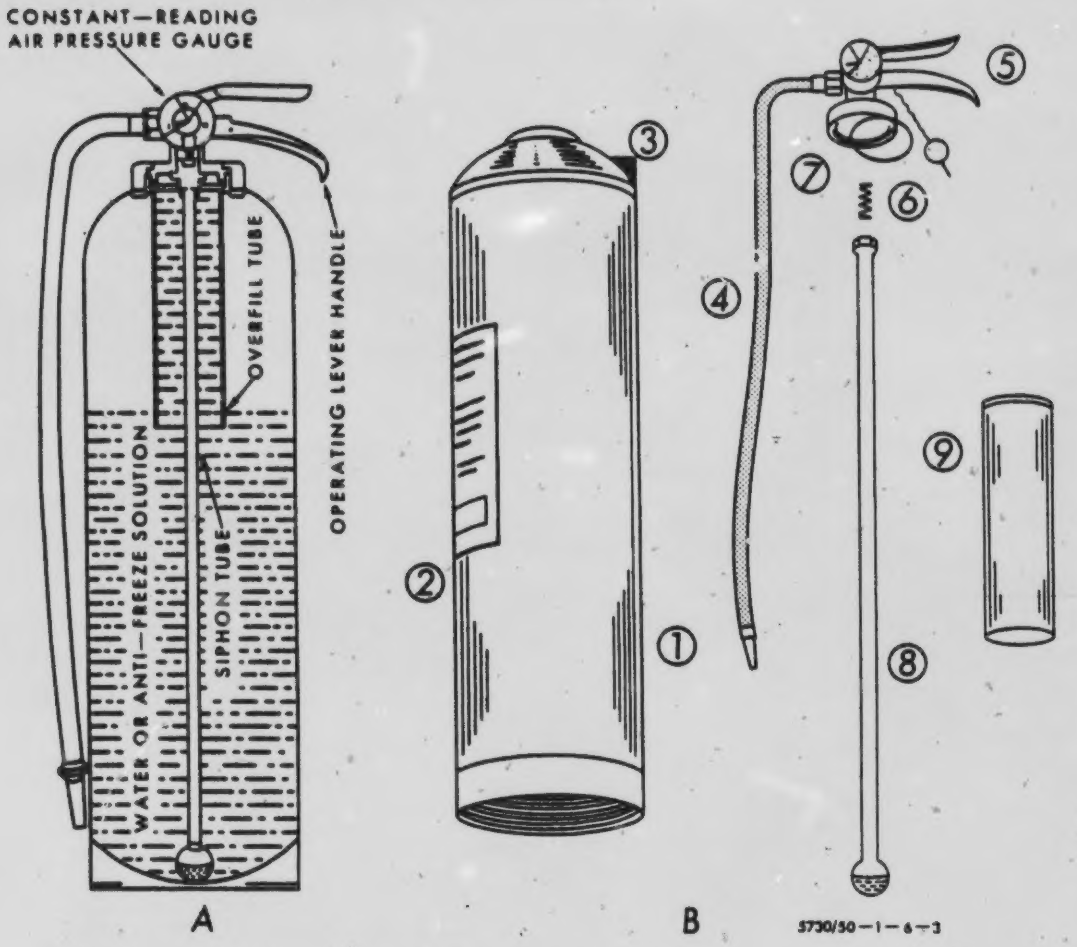
213. State procedures for inspecting various types of extinguishers.

The more common types of extinguishers that you may come in contact with are the water, carbon dioxide, dry chemical, and dry powder extinguishers. One or more of these extinguishers may be carried on the vehicles you are assigned to, but it is very doubtful if all of them will be on any one vehicle, unless that vehicle is especially designed for that purpose.

Pressurized and Stored-Pressure Water Extinguishers.

Most of these extinguishers are 2½ gallons in capacity. The different parts of the extinguisher are an outside shell, a discharge valve, a pickup tube, a hose, a nozzle, a pressure gage, and possibly a CO_2 cartridge (for stored-pressure water extinguishers only) as shown in figures 3-1 and 3-2. These extinguishers will deliver a stream up to 40 feet horizontally.

Inspection. When you make inspections on these extinguishers, check the seal attached to the safety pin for damage, check the air pressure gage for a correct pressure reading of 100 psi and condition of pressure gage. Also, examine the hose and nozzle for



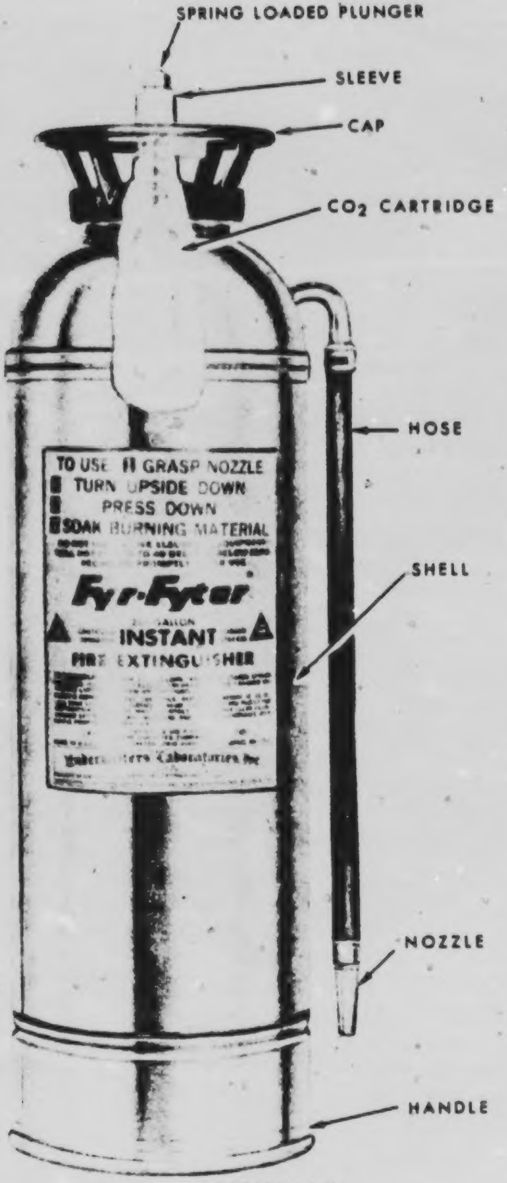
1. SHELL
2. INSTRUCTION PLATE
3. HANGER
4. HOSE
5. VALVE ASSEMBLY WITH PRESSURE GAUGE, DISCHARGE LEVER, CARRYING HANDLE, AND SAFETY PIN
6. DISCHARGE LEVER TENSION SPRING
7. GASKET
8. SIPHON TUBE WITH SCREEN
9. OVERFILL TUBE

Figure 3-1. Pressurized-water extinguisher.

foreign objects and damage and the overall condition of the extinguisher (dents, split seams and such). No semiannual inspection is required for these extinguishers except for the CO$_2$ cartridge-operated type. With this type, weigh the cartridge every 6 months to check for any CO$_2$ leakage. At the annual inspection, you must discharge the agent, clean the extinguisher completely, and recharge it with the proper agents.

Carbon Dioxide Extinguishers. Carbon dioxide is an inert gas that extinguishes fires by smothering rather than by cooling. The heat-absorbing capacity of carbon dioxide is very limited, being only 10 percent that of water. When carbon dioxide is stored under pressure in a cylinder or tank such as a fire extinguisher, it changes from a vapor to a liquid. When it passes through the discharge valve of a fire extinguisher, the change from a liquid to a gas and the expansion chill it to low temperatures so that approximately 30 percent of the liquid carbon dioxide is converted into solid carbon dioxide "snow" or "dry ice." Internal pressure generated by carbon dioxide stored in a tank or cylinder is proportional to the temperature; therefore, these extinguishers should not be placed in locations where heat is intense, and they must be protected from the direct rays of the sun during hot weather. At room temperature, the carbon dioxide gas exerts a pressure of more than 800 psi in the extinguisher. This high internal pressure at normal temperatures requires containers made of heavy materials. An empty 15-pound capacity extinguisher weighs approximately 35 pounds.

Carbon dioxide extinguishers are available in



57130/50-1-6-7

Figure 3-2. Stored-pressure water extinguisher.

content sizes from 2 to 100 pounds. The 15-pound hand extinguisher and the 50-pound hand-drawn wheel-type extinguisher, however, are the most common. All carbon dioxide extinguishers must be provided with the following two seals: a seal that is attached to the valve handle or wheel to hold the valve locking pin in place; and a plastic hood, or cap, placed over the safety valve to cover the frangible pressure-release disk. To insure the proper operation of carbon dioxide extinguishers, the seals must be standard replacement items, as designed by the manufacturers of carbon dioxide extinguishers.

Inspection. Inspections of carbon dioxide extinguishers should include checking pin seal on the extinguisher to insure that it is intact. Check the plastic seal to make sure that the seal is in place over the safety disk. Check the extinguisher location to make sure that it is not subject to high temperatures or in the direct rays of the sun; the hose for deterioration or weakness; and the horn for damage. A missing plastic seal may indicate a ruptured safety disk and an empty extinguisher. If either the pin seal or the plastic seal is missing, you must weigh, recharge (if necessary), and reseal the extinguisher.

The annual inspections of carbon dioxide extinguishers should include weighing the extinguisher to insure a full charge. At this time, you should also lubricate the running gears on wheel-type extinguishers. An extinguisher should be recharged if less than 90 percent of its carbon dioxide capacity is present. (This is the same as a greater-than-10-percent loss of the net capacity.)

Dry-Chemical Extinguishers. These extinguishers must not be confused with the dry powder kind. Dry-chemical extinguishers (sodium and potassium bicarbonate based) are designed for use on Class B and Class C fires. Multipurpose (ammonium phosphate) dry-chemical extinguishers are designed for use on Class A, Class B, and Class C fires. Dry-powder extinguishers are designed to extinguish Class D fires only, and the accidental use of dry-chemical extinguishing agents on Class D fires could result in injury or death. Various compounds of dry-chemical agents are used. Some of the more common ones are sodium bicarbonate, potassium bicarbonate, and an ammonium phosphate which is a multipurpose agent. These agents are chemically treated with a substance to keep them water resistant and free flowing. This also helps prevent packing of the chemical while stored inside the extinguisher.

These dry-chemical extinguishers may be found in sizes which range from 2½ to 30 pounds. The 30-pound size is the most common size used in the Air Force. The extinguishers may be cartridge-operated or may be of the stored-pressure type. As you can see in figure 3-3, the design of the stored-pressure type is very similar to the pressurized-water type we discussed earlier.

Inspection. The inspection includes checks of the hose, nozzle, and shell for leaks, cracks, and corrosion. At this time, also check that the cartridge is screwed tightly in position and that the seal is firmly in place. During the semiannual inspection, the cartridge must be weighed to determine if there has been a loss of not more than 10 percent of the expellent gas from the cartridge. If more than a 10 percent loss has

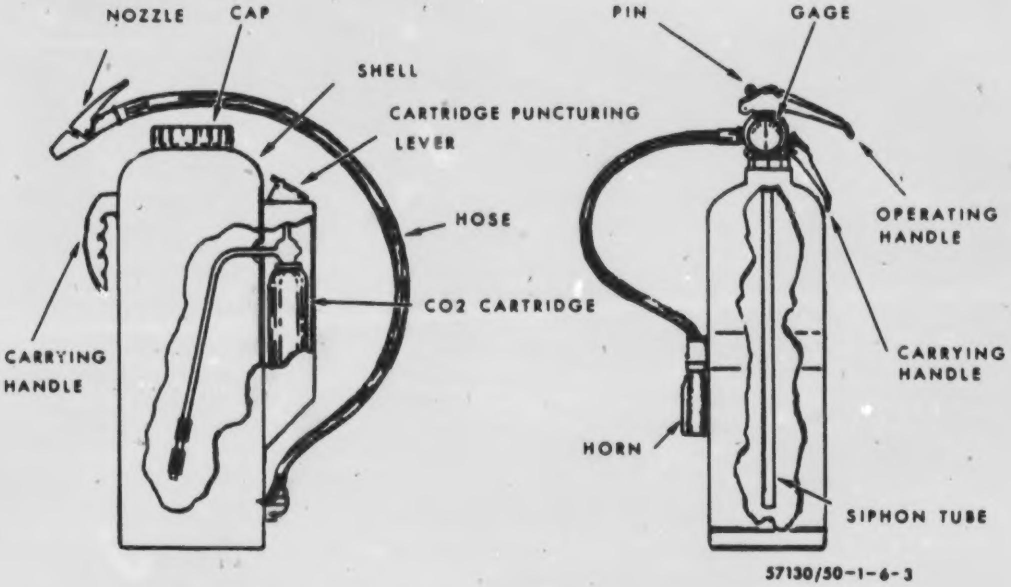


Figure 3-3. Dry chemical extinguisher.

occurred the cartridge must be replaced and/or recharged. The annual inspection includes all of the previous checks and inspections, plus a complete operational test, cleaning, and recharging.

Dry-Powder Extinguishers. Extinguishers of the dry-powder type are designed for use on Class D fires only. Their sizes may vary from the small 1-pound, to the 350-pound wheeled extinguishers. The 30-pound type is the most common type used in the Air Force. The agents used in the extinguishers may be in a powder or granule form. Using these agents on the wrong type of metal fire may result in a serious explosion, release of toxic gases, or both, thus endangering the user and others. You will find that one agent can be used on several types of metal fires, while another agent can be used only on one specific type of metal fire. These agents are also treated to remain water-resistive and free-flowing under stored conditions.

Inspection. The inspection procedures for these extinguishers are identical to those for dry-chemical extinguishers. One exception to this is worthy of discussion here. Certain dry-powder agents have no "extinguisher" but are always stored in the container used for shipping. These containers should be inspected for damage or exposure to water, as moisture may affect them. When these agents are needed for extinguishment, the lid is simply removed and the agent is scooped, shoveled, or thrown by hand onto the burning metal. Various types of dry-powder agents were discussed briefly in Chapter 1 of this volume. The tool which you may use to remove the lid from such an "extinguisher" could be an axe or a spanner wrench.

NOTE: Inspections on extinguishers are normally a part of the building fire inspection criteria. Frequency of inspections for extinguishers will be determined by the inspection of the building. Extinguishers found damaged by using organizations should be taken to extinguisher repair. The semi-annual and annual inspection referred to may or may not be required at your base, depending on local directives.

Exercises (213):

1. Which type water extinguisher must have a CO^2 cartridge weight-checked?

2. What should you check about the pressure gage of a water extinguisher?

3. Where are the seals located on carbon dioxide extinguishers (15-pound size)?

4. What would be an indication of a ruptured safety disk on a 15 pound carbon dioxide extinguisher?

5. When should the expellent gas cartridge be replaced in a dry-chemical extinguisher?

6. The inspection procedures for the dry-powder extinguishers are the same as those for the _______ - _______ extinguishers.

3-2. Testing Extinguishers

214. State when, how, and by whom extinguishers are service tested and hydrostatically tested.

There are several tests that the various extinguishers must undergo. These tests may be service tests, or hydrostatic tests. In most cases, the only test you will conduct will be the service test. The other test must be conducted with equipment not found in most fire stations.

Service Test. A service test of an extinguisher is nothing more than an operational test of the extinguisher to see that it is operating properly. Service tests are normally performed at least once a year during the scheduled maintenance cycle. When you make a service test, closely follow the directions on the extinguisher. Don't take short cuts with the test; follow the instructions to the letter; you might test an extinguisher the wrong way. Don't forget the hose on the extinguisher either. If it has a shut off type nozzle you must test the hose also.

Hydrostatic Testing. A hydrostatic test is an internal pressure check of the extinguisher cylinder to detect possible failure under pressure. Normally, the cylinder is filled with water (hydro) during the test. Hydrostatic tests also should be conducted immediately after discovering any indication of mechanical injury or corrosion to those extinguishers which exert internal pressure.

The test indicates whether the extinguisher parts are capable of withstanding a designated pressure. In general, the extinguisher is filled with water and liquid pressure is built up within the container or shell with a pump. Distortion, leaking, or rupture is a sign of failure. You must never use gas or air for pressure testing because the compressed air or gas would expand with destructive force in case of an extinguisher failure.

Extinguishers due hydrostatic test are normally sent to a testing facility. The following types of extinguishers are recommended to be tested every 5 years:

- Cartridge operated water.
- Stored pressure water.
- Dry chemical with soldered brass or stainless steel shells.
- Carbon dioxide – NOTE: CO^2 extinguishers with a cylinder made to DOT specifications should be tested according to DOT requirements.

Those types of extinguishers which should be tested every 12 years are:

- Halon 1211.
- Halon 1301.
- Cartridge operated dry powder.
- Stored pressure dry chemical with aluminum, brazed brass or mild steel shells.
- Cartridge-operated dry chemical with mild steel shells.

When an extinguisher fails a hydrostatic test, it must be destroyed. Other conditions which require the destruction of extinguishers are: (1) when the shell or cylinder threads are damaged; (2) the extinguisher has been burnt in a fire; or (3) pitting exists due to corrosion.

Exercises (214):

1. What type of test will you normally perform on an extinguisher?
2. Why should you follow the instructions on the extinguisher when you test it?
3. Why isn't air pressure used for hydrostatic test?
4. How often should a stored pressure water extinguisher undergo a hydrostatic test?
5. What should be done with an extinguisher that has been burnt in a fire?

3-3. Repair of Extinguishers

215. Briefly state the basic steps for repair and replacement of parts on extinguishers.

In a lot of cases, your repair of extinguishers will be limited to the replacement of parts or subassemblies. Before you start any work on an extinguisher, you should have the TO for the type and model you will be working on. If there is no TO for that extinguisher, try to locate the manufacturer's literature. You shouldn't try to work on an extinguisher without some guidance, because you may do more damage than good – perhaps even cause serious injury to yourself or others.

Before trying to disassemble any extinguisher, be sure all pressure has been relieved from inside the shell. *Don't* trust the pressure gage either, they have been known to lie. If there is no bleed off valve, invert the extinguisher from its normal operating position and operate the discharge valve. (This does not apply to CO^2 extinguishers.) Once you are sure all pressure has been relieved, you can remove the cap from the extinguisher. Be sure that you use all the safety equipment and clothing during all phases of operation.

As you remove each piece, inspect it for damage and check its operation, if you can. Inspect all gaskets and/or seals and replace any showing defects. If there is any doubt as to the condition of a gasket, replace it.

For the most part, you won't be trying to repair gages, hoses, or head/cap assemblies. You may replace ruptured safety disks in heads or operating levers, but that is usually as far as it goes. When more needs to be done, the extinguisher is normally replaced. Never try to beat dents out of an extinguisher shell. When the shell is damaged to such a degree, it should be replaced.

Nozzles and chassis parts for extinguishers should be repaired as much as possible. Often times, you can use two or three damaged items to make up one serviceable item. A little work and time on your part could save "Uncle Sam" a good bit of money. Be sure you make a full operational test of any part you repair before installing it on an extinguisher that is to be issued. If the part doesn't work right, chances are good the extinguisher won't do its job.

A good supply of spare parts will allow you to exchange parts of an extinguisher and return it to the using activity in minimum time. The parts that you replaced can then be repaired and tested when the work load drops off somewhat.

Exercises (215):

1. Before starting work on an extinguisher, what should you do?

2. How do you pressure bleed an extinguisher without a bleed-off valve?

3. What should you do with an extinguisher that has a badly dented shell?

4. What should you do with repaired extinguisher parts before installation on issued extinguishers?

3-4. Recharging Extinguishers

216. Give procedures for recharging various types of extinguishers.

Now that we have inspected, tested, and repaired our extinguishers, we are ready to recharge them and to winterize them, if necessary.

Pressurized or Stored-Pressure Water Extinguishers.

To recharge either the pressurized or the stored-pressure type of extinguisher, first invert the shell from the operating position and bleed off any remaining pressure by operating the discharge valve. Then remove the cap and fill the shell with the proper amount of water or antifreeze solution. In the stored-pressure type, replace the CO^2 cartridge with a full one. Be sure to lubricate the gaskets in the caps and check them carefully for grooving, dryness, and cuts. Replace the caps. The stored pressure is now ready for use. The pressurized-water type will need the addition of air or nitrogen through the air chuck connection in the cap. Be sure that the correct pressure of 100 psi is reached, and that the unit is not leaking.

Winterization. During nonfreezing periods, plain water is usually kept in these extinguishers. A commercial type of antifreeze solution is used in the extinguishers that will be subjected to freezing temperatures. It is not suggested that calcium chloride be used as an antifreeze agent in these extinguishers. For winter use, replace the CO^2 cartridges with nitrogen cartridges in order to make sure that enough pressure will be present at all times to expel the water. The pressurized-water extinguisher will require charging with dry nitrogen.

Carbon Dioxide Extinguishers. Carbon dioxide extinguishers may be charged by commercial charging plants, transfer pumps, or bypass filling units. The extinguishers should be recharged after any use, also periodically, and when they fall below 90 percent of their rated weight capacity. Recharging must be done only by qualified personnel. Extremely high pressures are encountered, so every care must be taken to insure secure connections, adequate valves, and safe practices. When safe and adequate charging facilities are not available, the extinguishers should be shipped to the nearest commercial charging plant. The manufacturer usually furnishes a list of charging plants with each extinguisher.

Charging by transfer pump. As you can see in figure 3-4, the transfer-pump unit consists of a small, high-pressure pump driven by an electric motor or gasoline engine, a set of scales, spare 50-pound commercial cylinders (the transfer pump may be connected to a carbon dioxide storage unit if your base is authorized one), tilting racks, wrenches (not shown in fig. 3-4), and the necessary piping and fittings. The transfer-pump unit should be used for carbon dioxide only; it

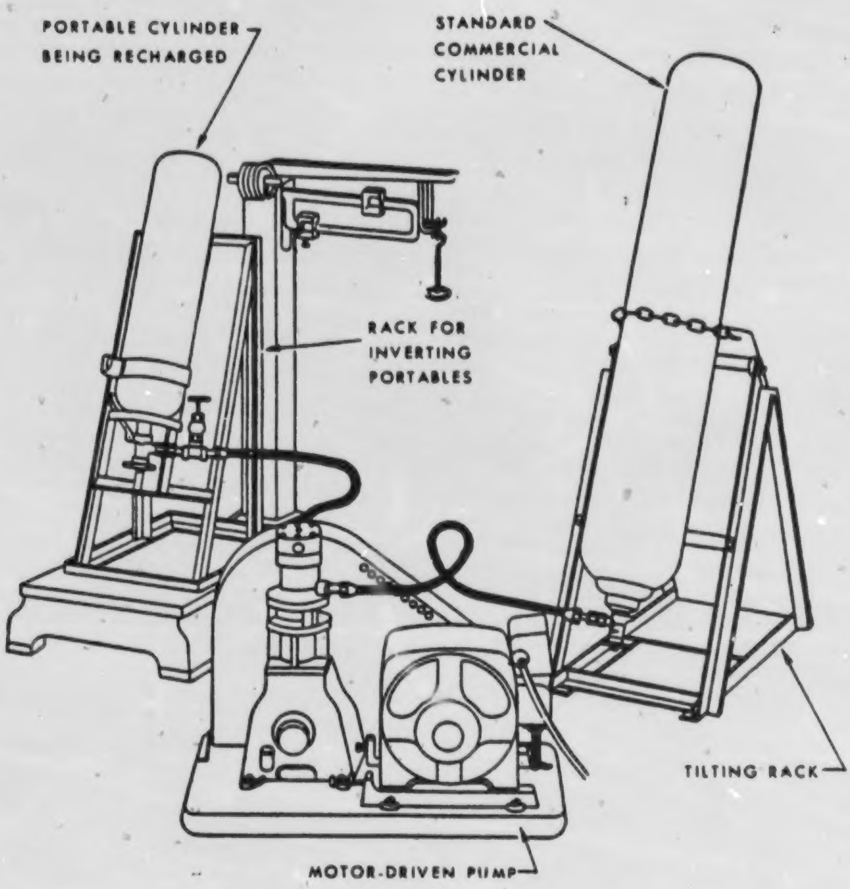

PORTABLE CYLINDER BEING RECHARGED
STANDARD COMMERCIAL CYLINDER
RACK FOR INVERTING PORTABLES
TILTING RACK
MOTOR-DRIVEN PUMP

Figure 3-4. Transfer-pump unit.

must not be used for oxygen or other gases. Always keep the extinguisher cylinder being charged as cool as possible to insure an efficient transfer. The time required to charge an empty cylinder increases with the temperature of the cylinder. Inverting the extinguisher cylinder will keep it cooler and permit faster filling. This is also shown in figure 3-4.

After all of the liquid carbon dioxide (approximately 80 percent of the net contents) is transferred from the supply cylinder, use a fully charged supply cylinder to bring the extinguisher cylinder to its full-rated capacity. Most of the gas in partially spent supply cylinders can be used to start charging other empty extinguisher cylinders, since the gas will transfer itself under its own pressure until the pressure in both the supply and extinguisher cylinders is the same.

Supply cylinders ordered from commerical manufacturers of carbon dioxide should have a normal discharge outlet opening of at least 1/8-inch diameter and a valve-passage opening of 3/16-inch diameter. These diameters prevent the carbon dioxide from expanding in the supply hose and clogging the hose with carbon dioxide snow. A standard commercial 50-pound cylinder contains approximately 38 pounds of liquid carbon dioxide and 12 pounds of gas at 70° F. If the temperature is lower, more of the carbon dioxide will be in a liquid state, at a reduced pressure. If the temperature is higher, less will be in a liquid state, at an increased pressure. However, in each case, there will be a total of 50 pounds of carbon dioxide in the cylinder. Detailed instructions are provided in the following paragraphs to help you prepare for the transfer of CO_2 from the supply cylinder and to recharge the extinguisher.

Preparation. You should arrange the pump, scale, tilting racks, and supply cylinder in the same general arrangement as shown in figure 3-4. Place supply cylinders without siphon tubes upright in the tilting rack, secure in place with a chain, and invert them. If a supply cylinder has a siphon tube, use the cylinder in an upright position, so as to transfer liquid rather than gas.

Next, you can connect the inlet hose of the pump to the supply cylinder outlet. The connection adapter of this hose is fitted with a screen to keep foreign matter from entering the extinguisher. The supply cylinder valve must not be opened at this time.

When a 2-pound extinguisher is provided with a seat-type valve, as shown in figure 3-5, unscrew the horn from the tube and attach a recharging adapter to the end of the tube. For 4- to 20-pound extinguisher cylinders with seat type and squeeze-grip (not shown) valves, you unscrew the tube and discharge-horn assembly at the cylinder-valve connection. Then you may need to attach a recharging adapter at the cylinder valve connection.

To recharge an extinguisher cylinder with a disk-type valve, such as that shown in figure 3-6, unscrew the cutter head, shown in A of figure 3-6. The cutter head has left-hand threads. Place the filling bonnet stem in the bonnet and screw the assembly on to the cylinder valve. Seat the filling bonnet stem into the disk bushing. Use the filling bonnet wrench to unscrew the disk bushing. Unscrew the filling bonnet and disk bushing from the cylinder valve. Now clean the disk bushing seat. Replace the ruptured disk bushing with a new one and lightly seat it in the cylinder valve. Place the filling bonnet assembly on the cylinder valve and screw it down firmly. Use the filling bonnet wrench to unscrew the disk bushing as far as possible.

Connect the outlet hose of the transfer pump to the recharging adapter (seat type and squeeze grip) valve or to the filling bonnet (disk type valve) on the extinguisher cylinder. Check all connections to make sure that they are properly and securely made. Check to see that the shutoff valve in the pump outlet hose is tightly closed. Screw open the handwheel of the seat-type valve, or secure open the squeeze-grip valve. Place the empty extinguisher cylinder on the scale. If you can, invert the cylinder on the scale by means of the tilting rack. Larger cylinders that you cannot invert may be placed horizontally on the scale with the bottom of the extinguisher raised slightly.

Determine the net capacity and total weight of the extinguisher to be recharged. Set the scale at the fully charged weight, which is indicated on the cylinder valve, the cylinder, or the nameplate band.

Charging process. To recharge an extinguisher cylinder, open the valve of the supply cylinder fully. Open the shutoff valve in the pump outlet hose to allow carbon dioxide to transfer under its own pressure from the supply cylinder to the cylinder being recharged.

When the carbon dioxide stops flowing under its own pressure, the pressure of the cylinder being recharged is equal to that of the supply cylinder. Then start the transfer pump and watch the scale carefully until the full capacity of the cylinder is reached. When the extinguisher cylinder is fully charged, you do three things in rapid succession: Stop the transfer-unit motor; close the shutoff valve in the pump outlet hose; and close the filling bonnet or valve of the extinguisher cylinder. Then you slowly disconnect the pump outlet hose from the recharged cylinder to release the pressure trapped between the shutoff valve and the cylinder. Do not touch frosted metal parts with your bare hands, since frozen fingers or skin may be the result. (CAUTION: *Do not close the filling bonnet, extinguisher valve, or shutoff valve in the pump outlet hose while the transfer unit is pumping. Pump pressure will build up and possibly burst the hose or valve.*)

After extinguishers with seat-type valves are charged, close the extinguisher valve by turning the handwheel. After the valve is closed, loosen the setscrew of the adjustable ring, or collar, under the handwheel. Turn the collar until the holes in the collar and handwheel are aligned. Insert the locking pin in the holes and tighten the setscrew of the lockpin ring. Attach the copper wire and lead seal to the locking pin, and test the extinguisher valve under water for leakage.

After extinguishers with disk-type valves are charged, close the filling bonnet by threading the disk bushing down tightly with the special wrench in the filling bonnet. After the filling bonnet is closed, unscrew it from the cylinder valve and test the entire cylinder-valve assembly under water for leakage. See that the cutter in the cutter head is sharp and is not damaged. Insert the locking pin in the handwheel of the cutter head and attach the lead seal and copper wire. Then thread the cutter head to the cylinder valve and tighten lightly with a wrench.

Weigh the recharged cylinder to insure that it is filled with the proper quantity of carbon dioxide, and install the plastic cover over the safety disk (figs. 3-5 and 3-6). When recharging is finished, close the supply cylinder valve and slowly open the shutoff valve in the pump outlet hose to allow all the gas in the pump to discharge.

Charging by bypass filling unit. A carbon dioxide bypass filling unit, as shown in figure 3-7, is used to recharge portable cylinders without using pumping equipment. The bypass filling unit connects a standard commercial supply cylinder and the portable extinguisher cylinder being recharged. The transfer of carbon dioxide, using the bypass unit, depends on a difference of temperature and corresponding difference in pressure between two cylinders. As gas is compressed in filling an empty extinguisher cylinder, that cylinder is heated. As gas under pressure leaves a supply cylinder, that cylinder is cooled. A supply cylinder must be allowed to

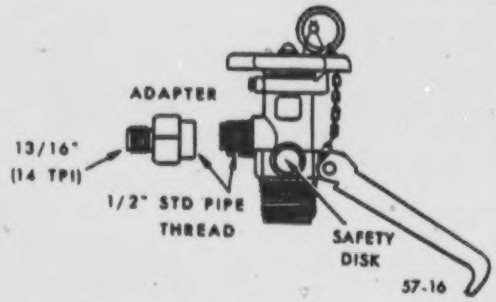


Figure 3-5. Extinguisher-seat type valve.

warm to room temperature after each extinguisher is recharged.

You can get a full charge of liquid CO^{2} in the extinguisher by allowing all of the liquid that will transfer to do so (invert both tanks so that liquid goes from the supply tank to the extinguisher). Flow will stop when the pressure in the two tanks equalizes. Then, you can chill the extinguisher tank by closing the supply tank valve, then bleeding off some of the gas from the extinguisher tank by means of the bypass valve in the transfer hose. When the extinguisher tank is chilled, you can again transfer liquid from the supply tank. These steps are repeated until you have a complete charge.

After the extinguisher is filled, close the valve on the supply cylinder and the valve on the extinguisher. Then bleed the bypass filling unit to remove the gas and disconnect it from the cylinder. In practice, after two 15-pound extinguishers have been charged from a single supply cylinder, the pressure differential is so low that only a small amount of gas will enter a third cylinder.

Dry Chemical Extinguishers. Before recharging the dry-chemical extinguisher, you must first invert the extinguisher and bleed off any remaining pressure, as we discussed previously. Then remove the cap and fill the shell with the proper amount and type of dry chemical. Remove the used CO^{2} cartridge and replace with a full one. Some extinguishers may have the cartridge mounted on the side of the shell or attached inside the shell. Refill only with type of chemical indicated on shell or approved substitute, do not mix chemicals or powder. Be sure to replace any defective gaskets. Replace the cap and seal. This completes the recharging.

Winterization. The dry chemicals will not freeze, but freezing temperatures may reduce the carbon dioxide cartridge pressure too low to expel the dry-chemical agent. To make sure that this doesn't happen, replace the CO^{2} cartridge with a cartridge of nitrogen.

Dry Powder. Dry powder extinguishers are recharged in the same manner as dry chemical extinguishers. Again be very careful to get the correct agent into the extinguisher. One moment of carelessness could cost a life if the wrong agent

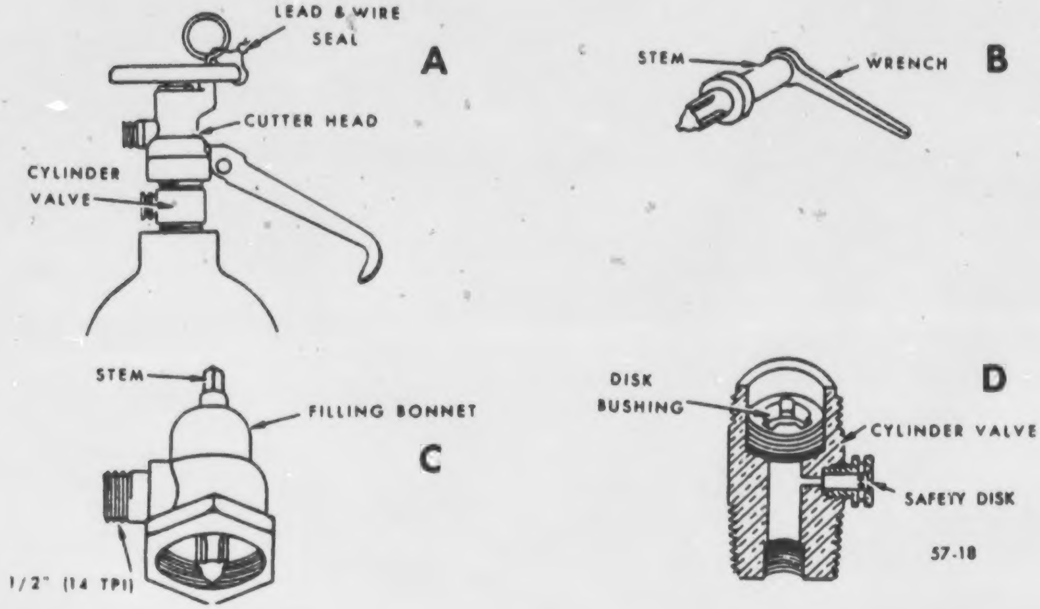


Figure 3-6. Extinguisher-disk type valve.

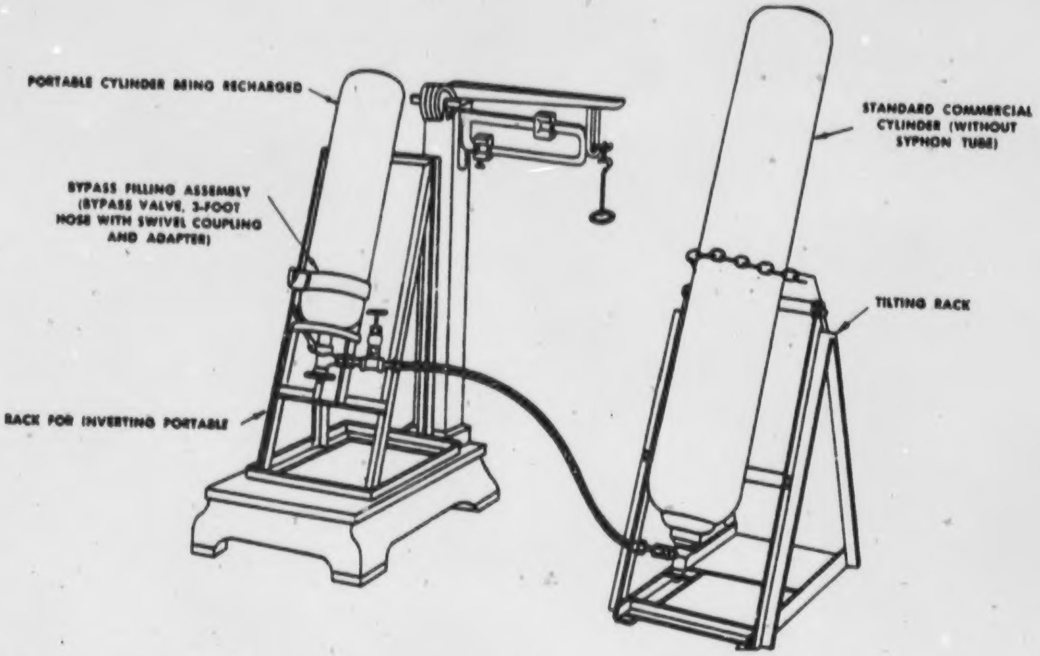

PORTABLE CYLINDER BEING RECHARGED
BYPASS FILLING ASSEMBLY (BYPASS VALVE, 3-FOOT HOSE WITH SWIVEL COUPLING AND ADAPTER)
RACK FOR INVERTING PORTABLE
STANDARD COMMERCIAL CYLINDER (WITHOUT SYPHON TUBE)
TILTING RACK

Figure 3-7. Bypass filling system.

is used. If the dry powder is to be used from its shipping container, insure it is "free-flowing" and not caked. If caked, replace the container and agent.

Exercises (216):

1. In recharging a stored-pressure water extinguisher, you should check the gasket in the cap for ______ , ______ , and ______ .

2. During winter, the pressurized-water extinguisher should use ______ for expelling the agent.

3. When must CO^2 extinguishers be recharged?

4. When you recharge carbon dioxide extinguishers, why must you take extreme care?

5. How does the temperature of the empty cylinder affect the time required to fill that cylinder?

6. Why should a supply cylinder have at least a 1/8-inch discharge outlet opening and a 3/16-inch valve-passage opening?

7. Why should a supply cylinder with a siphon tube be in an upright position to recharge CO^2 extinguishers using a transfer pump?

8. How is the outlet hose of the transfer pump connected to a CO^2 extinguisher cylinder that has a squeeze grip valve?

9. While servicing a 15-pound CO^2 extinguisher, you note that the empty weight of the extinguisher is 34½ pounds. What should the scale be set at when you recharge this extinguisher?

10. When the scale indicates that the CO^2 extinguisher you are recharging is full, what must you do before you close the filling bonnet head?

11. What will happen if you do not take the necessary action, in proper sequence, when you shut down after recharging a CO^2 extinguisher using a transfer pump.

12. How are the holes lined up on seat-type valve CO^2 extinguishers to insert the locking pin after the extinguisher has been charged?

13. How can you recharge a 15-pound CO_2 extinguisher without using a transfer pump?

14. The bypass filling unit operates on what principle?

15. What is the first step in recharging a dry-chemical extinguisher?

16. What may happen to a dry-chemical extinguisher if the CO_2 cartridge isn't replaced by one of nitrogen during freezing temperatures?

17. What agent should be used to reservice a dry powder extinguisher?

CHAPTER 4

Fire Protection Hydraulics and Prefire Plans

AT FIRST, you may think that these are two very dissimilar subjects to discuss in the same chapter. Once you think about it for a couple of minutes, you can see where the use of hydraulics is needed to supply some of the information that will go on the prefire plans.

Hydraulics is that branch of science or engineering which deals with the properties of water or other liquids while they are at rest or in motion. It is not necessary, of course, that firefighters be hydraulic engineers. However, you must understand the importance of hydraulics and be able to apply it in a practical manner at the scene of a fire. Inadequate training or lack of experience in fire protection hydraulics can be extremely costly in an emergency. This directly affects each person in carrying out his assigned mission.

Fire is your opponent – your enemy. You should analyze your particular problems and make your prefire plans. Obviously, these plans must be subject to radical revisions on the spot in the event that the expected and planned-for situation does not develop. In such a case, all you have to face is the unexpected; you still have the advantage of your plans for the expected. As a matter of fact, the only difference between the expected and the unexpected in prefire planning might well be the difference in how thoroughly and exhaustively you analyzed the situation, and how intelligently and effectively you mapped your plans to take care of every possible situation. You should always know where the fire can occur and what equipment and personnel you have available. Then you need only to make your plans accordingly, to use what you have at your disposal. Can you do this more efficiently with previous planning, or without it? The answer is very clear – WITH!

4-1. Hydraulics

Water, the most common liquid, is also the most effective in its many forms for the purpose of firefighting. To use water most effectively, you must know something about its physical properties. For all practical purpose, water is NOT compressible. It is necessary to exert 30,000 pounds of pressure per square inch to reduce the volume of water one percent. If the water has a mineral content or is subjected to different temperatures (not freezing), it will vary slightly in its characteristics. These variations are so slight, however, that you need not worry about them.

217. Compute head and back pressure, rate of discharge, friction loss and drafting requirements; and briefly explain the means of computing them.

Properties of Water. Water consists of two parts of hydrogen (H^2) and one part oxygen (O), and it is written as H^2O. The following are some measurements of water which you should remember:

- 1 gallon of water weights 8.35 pounds.
- 1 gallon of water contains 231 cubic inches.
- 1 cubic foot of water contains 1728 cubic inches.
- 1 cubic foot of water contains 7.481 gallons (commonly rounded off to 7.5 gallons).
- 1 cubic foot of water weights 62.5 pounds.

Firefighters should know how to find the weight of any given quantity of water. Some of the reasons are to determine when it is safe for loaded vehicles to cross a bridge, to determine the load imposed on floors by the water used to extinguish fires, and to determine the weight of charged hose lines. For example, a vehicle with water capacity of 1000 gallons actually has 8350 pounds of water aboard. This is determined by multiplying 8.35 (the weight of 1 gallon) by 1000 (the number of gallons). This is more than 4 tons of water, which might well mean the difference between detouring around or crossing over a bridge of limited capacity.

The futility of filling a 2½-inch 50-foot section of hose with water before trying to move it is demonstrated by the following problem: In order to figure the weight of water in a 2½-inch 50-foot section of hose, you can use the formula:

$$V = \frac{D^2 \times .7854 \times h \times 8.35}{231}$$

Now "h" is the length of the hose in inches (50 feet equals 600 inches). "D" is the diameter of the hose in inches (2½), 231 is the number of cubic inches in a gallon, 8.35 is the weight of a gallon of water, and .7854 is the number which will convert D^2 to the area of a circle (the hose). Now, by putting in the numbers and squaring the D ($2\frac{1}{2} \times 2\frac{1}{2} = 6.25$)

$$V = \frac{6.25 \times .7854 \times 600 \times 8.35}{231}$$

This will give you the answer to the problem of 106 pounds of water (rounded off to the whole number).

Add to the 106 pounds of water the 65 pounds of hose, and you have a total weight of 171 pounds per charged section of hose. To move by hand four 50-foot sections of 2½ inch hose up a ladder becomes an impossible task. The weight to be moved would be 684 pounds. We would also find that 1000 feet of 2½-inch charged hose involves over 3420 pounds to be moved.

Head Pressure. Head is the term used to describe the vertical distance between the top of the water at the source and the point of discharge. For example, the vertical distance between the top of the water in a given tank and a certain hydrant outlet (at or near ground level) could be 60 feet. The "head" of water in this example is 60 feet. "Pressure" is that pressure caused by the depth of water, and in hydraulics it is measured in pounds per square inch (psi). Now remember, a cubic foot of fresh water weighs about 62.5 pounds. A cubic foot of water can be divided into 144 columns as shown in figure 4-1. Each column is 1 square inch in area at the base and 1 foot high. How much does one of the 144 columns weigh? This is determined by dividing the number of columns (144) into the weight of the cubic foot (62.5 pounds). The answer to this problem is that each column 1" × 1" × 12" weighs .434 pounds. A column of water 1 square inch at its base and 1 foot high weighs .434 pounds and exerts a pressure in pounds per square inch at the base of the column of water of .434 psi. We would find that the total pressure of a column of water is .434 multiplied by the height, in feet, of the column. This is expressed as $P = .434 \times H$. (P = pressure, and H = head in feet.) For a quick example of the use of this formula we would see that a water tower 100 feet high would exert a water pressure of 43.4 psi ($P = .434$ H, or $P = .434 \times 100$).

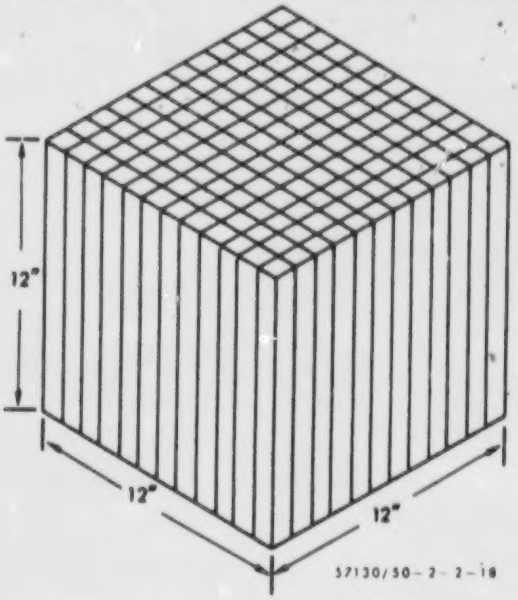


Figure 4-1. 1 cubic foot.

Back Pressure. Back pressure is indicated in psi and is the pressure caused by gravity and the weight of the water. It is a special term used to indicate the pressure which is pushing "back" against a pump. An example would be a hose line taken to the third floor of a building. The gravity pressure against the rising water in the hose is called back pressure. To determine the amount of back pressure, you can use the same formula that we used to find head pressure, or BP = .434H. Since nearly all Air Force buildings that have more than one floor average about 11.5 feet per floor, a good rule of thumb for determining back pressure is to use a 5 psi loss per floor, or 10 psi loss to the third floor.

$$BP = .434H = .434 \times 11.5 = 4.99, \text{ or } 5 \text{ psi}$$

Your work in operating pumpers will require you to remember how to determine back pressure.

Rate of Discharge. The ideal structural firefighting stream must be capable of discharging 9/10 of its volume within a 15-inch circle at a distance of 0 to 80 feet. The nozzle pressure should be approximately 50 psi. The *rate of discharge* is the quantity of water issuing from an opening during a given period of time. It is measured in gallons per minute (gpm). When the rate of discharge is computed, two items must be considered: the area of the opening, such as the nozzle orifice, and the velocity of the flow. The rate of discharge is found by multiplying the area by the velocity. This is written as: discharge in gpm = $29.7 \times D^2 \times \sqrt{P}$, where P = the pressure of water in psi ($\sqrt{P}$ means square root of P), D = the diameter of the nozzle in inches, and 29.7 is a constant which takes into account such items as the number of seconds in a minute, the number of cubic inches in a gallon, the number of inches in a foot, and other figures in mathematics which we do not need to remember, since they would make too cumbersome a formula to use. Since those values are constant, you can use the simple formula in which all the constants are combined to give a single constant of 29.7. As a result of this, you will always use the formula for discharge in gallons per minute as, Dis = $29.7 \times D^2 \times \sqrt{P}$.

Now, use this formula to find the discharge in gallons per minute from a 1¼-inch tip with a 50-pound nozzle pressure.

$$\begin{aligned} D &= 1.25;\ P = 50,\ \text{so we have} \\ \text{Discharge} &= 29.7 \times D^2 \times \sqrt{P} \\ &= 29.7 \times 1.25^2 \times \sqrt{50} \\ &= 29.7 \times (1.25 \times 1.25) \times 7.07 \\ &= 29.7 \times 1.5625 \times 7.07 \\ \text{Discharge} &= 328 \text{ gallons per minute} \end{aligned}$$

An open hose butt or hose coupling, or an average hydrant outlet, is only about 90 percent as efficient as a nozzle tip in terms of water volume discharge for a given size and pressure. So, for open-butts or hydrant discharge in gallons per minute, the formula you have just applied to nozzle discharge must be multiplied by .90. Dis = $29.7 \times D^2 \times \sqrt{P} \times .90$. If we apply this to a $2^1/_2$-inch hydrant with a pressure of 25 psi, then:

$$\begin{aligned} \text{Discharge} &= 29.7 \times D^2 \times \sqrt{P} \times .9 \\ &= 29.7 \times 2.5^2 \times \sqrt{25} \times .9 \\ &= 29.7 \times 6.25 \times 5 \times .9 \\ &= 835 \text{ gpm} \end{aligned}$$

NOTE: For a more precise calculation, 29.83 may be substituted for 29.7 in hydraulic calculations. The figure 29.83 is used more and more often because it does give a more accurate answer. However, for the purpose of this course, 29.7 will be used for all hydraulic calculations.

Friction Loss. Friction is the resistance to motion between two substances in contact. The term "friction loss," as used in fire protection hydraulics, means the loss of *pressure* due to friction. The friction with which fire protection hydraulics is concerned is caused by the flowing water rubbing against the inside of the fire hose. This causes turbulence in the water, which in turn sets up another cause of friction — that of water rubbing against water.

The rubber linings of firehoses appear perfectly smooth to the naked eye, under magnification the hose linings appear as a series of surface irregularities which increase in size as water pressure increases in the hose. These irregularities slow down the speed of the water as it travels through the hose under pressure, causing a friction loss, which in turn decreases the amount of water pressure at the nozzle. As you have already learned, the amount of water *discharged* from a hose is determined by the amount of nozzle pressure and the size of the outlet. Friction loss in a hose will cause a loss of discharge pressure, which in turn causes a loss in volume of flow.

In dealing with friction loss, there is a law of pressure with which you should be familiar: The water pressure at the source minus the pressure lost on the way equals the pressure at the nozzle. The pressure acquired in the beginning is the *engine pressure*. The pressure lost on the way is the *friction loss*. The remaining pressure is the *nozzle pressure*. Engine pressure minus friction loss equals nozzle pressure (NP = EP - FL); or, to put it another way, nozzle pressure plus friction loss equals engine pressure (EP = NP + FL). These formulas are rule of thumb and can speedily be applied at a fire or emergency scene.

Friction loss increases directly as hose length increases; the loss being twice as great for 200 feet as for 100 feet of hose. When the *rate of flow* increases, however, friction loss increases at almost *twice* the rate. Doubling the *amount* of water flowing makes the friction loss approximately *four times* as great. You can see from this that hose length and rate of flow are the two factors that determine the amount of friction loss in a hose line. When there is a given friction loss for 100 feet of a certain size hose, the friction loss in 200 feet of the same size hose will be twice that; and for 300 feet it will be three times that for 100 feet, etc. As the hose decreases in size, friction loss increases because a greater speed of flow is necessary for a given volume of flow. Then, the faster the water is forced through the hose, the greater the friction loss.

Friction loss per 100-feet in psi, and discharge in gallons per minute (gpm) using a 2½-inch hose with 50-pounds nozzle pressure is shown below.

Nozzle Size	*Friction Loss*	*Gpm*
¾"	4 psi	118
⅞"	8 psi	160
1"	10 psi	210
1⅛"	18 psi	265
1¼"	25 psi	325
1½"	50 psi	470

Since you will also be using 1½-inch hose lines, the friction loss per 100 feet of 1½-inch hose with 50-pounds nozzle pressure is given.

Nozzle Size	*Friction Loss*	*Gpm*
⅜"	3 psi	30
½"	10 psi	50
⅝"	25 psi	80

The figures are approximate but are close enough for practical purposes. In the preceding tables, a standard discharge pressure of 50 psi is used. You will sometimes have to work with discharge pressures other than 50 psi, so you must know how to compute the friction loss per 100 feet of hose at all discharge rates.

Since friction loss is the loss of pressure due to the friction and turbulence set up between the flowing water and the hose lining, it follows that if you increase the amount of water flowing you will increase the friction loss. The formula for determining friction loss is therefore based on gpm flow. For a 2½-inch hose it is:

60

Friction loss = $2Q^2 + Q$ (or $2 \times Q \times Q + Q$)

Q is the quantity of water flowing in hundreds of gallons per minute. The quantity in hundreds of gpm is determined by the following formula:

$$Q = \frac{gpm}{100}$$

Example 1: 200 gpm are flowing through a 2½-inch hose. What is the friction loss per 100 feet of hose?

200 gpm : 100 = 2 hundreds of gallons
$2 \times 2 \times 2 + 2 = 10$ psi loss per 100 feet

Example 2: 350 gpm are flowing through a 2½-inch hose. What is the friction loss per 100 feet of hose?

350 gpm : 100 = 3.5 hundreds of gallons
$2 \times 3.5 \times 3.5 + 3.5 = 28$ psi loss per 100 feet

When flow is less than 100 gpm, more accurate results will be obtained by using the formula $2Q^2 + (\frac{1}{2})Q$.

Example 3: 80 gpm are flowing through a 2½-inch hose. What is the friction loss per 100 feet of hose?

80 ÷ 100 = 0.8 hundreds of gallons
$2 \times 0.8 \times 0.8 + 0.4 = 1.68$ psi loss per 100 feet

Now use this formula to work out the frictoin loss in 2½-inch hose lines for different size nozzle tips and see how close your answers are to those in the tables.

Pump Operator's Guide Plate. Most structural pumpers employed by the Air Force are equipped with a pump operator's guide plate directly over or near the pump controls. This plate, illustrated in figure 4-2, lists the pump pressures required to maintain a desired nozzle pressure for different size nozzle tips and hose lengths and is used merely as a guide by pump operators. A heavy, zig-zag line divides the guide plate in half, indicating the correct setting for the "changeover valve" in a multiple-stage pump. The line has no significance in operating a single-stage pump, because it does not have a changeover valve. Several pumpers used by the Air Force have two-stage pumps, which means that the pump has two sets of impellers. When the valve is placed in the VOLUME, or PARALLEL position, the water entering the pump on the intake side is divided and delivered to both sets of impellers simultaneously. Then, as the impellers force the water out of each impeller housing, the two masses of water join together before emerging from the discharge outlet. When the valve is placed in the PRESSURE, or SERIES position, the water entering the intake side is delivered to one impeller, which forces the water through an orifice to the other impeller, which in turn forces it out as increased pressure through the discharge outlet.

If you are operating a two-stage pump with a changeover valve and are pumping at a pressure listed to the left of the heavy line, be sure that the changeover valve is in the VOLUME (or PARALLEL) position. If you are pumping at a pressure listed to the right of the line, see that the changeover valve is in PRESSURE (or SERIES) position.

Drafting. Drafting is the process of pumping water from such auxiliary sources as lakes, ponds, rivers, wells, or swimming pools. In this process, the pump maintains a partial vacuum within the pump volute and suction hose so that the atmospheric pressure on the surface of the water forces the water up the suction hose and into the pump.

The height to which water can be drafted is governed by the atmospheric pressure. The higher the altitude of drafting, the less the atmospheric pressure, and thus the height to which water can be raised decreases. For each 1000-foot increase in altitude, the atmospheric pressure decreases by about 0.5 psi, and the height to which water can be raised by drafting decreases by 1.15 feet.

SIZE OF NOZZLE	G.P.M.	NOZZLE PRESSURE IN POUNDS	LENGTH OF 2-1/2 INCH HOSE LAYOUT									
			100	200	300	400	500	600	700	800	900	1000
			REQUIRED PRESSURE AT PUMP									
1"	209	50	62	73	84	95	106	117	128	139	150	160
1-1/8"	265	50	69	86	103	120	137	154	171	188	205	222
1-1/4"	326	50	78	103	128	153	178	203	228	253	278	303

Figure 4-2. Pump operator's guide plate.

(Climatic conditions may vary this figure slightly.) The theoretical height to which water can be lifted is 33.9 feet at sea level. This figure is arrived at by multiplying 14.7 psi (the atmospheric pressure at sea level) by 2.304 (the head of water necessary to create 1 pound of pressure per square inch). This figure of 33.9 feet is only theoretical, for it would require a perfect vacuum to raise water to this height, and fire pumps cannot produce a perfect vacuum. The practical height to which water can be lifted is about 75 percent of the theoretical height if the pump is in good condition and well maintained. This would be about 25 feet of lift as the maximum.

In drafting water, one more element other than atmospheric pressure must be considered. This element is the friction loss created in the suction hose and strainer. Suction hose, like any other hose, has the element of friction loss. The larger the suction hose, the less friction loss and, therefore, the greater the height to which water can be lifted. For example, a pump that can lift 400 gpm vertically 24 feet with a 5-inch suction hose can lift the same amount of water only 17 feet with a 3½-inch suction hose. If your suction hose is too small, the pump may pull a vacuum which imposes an unnecessary load on the pump, and pressure loss may result. You should remember that to draft water, all connections on the intake side of the pump *must* be tight. An air leak will destroy the partial vacuum and, as a result, water cannot be drafted.

Exercises (217):

1. What is the formula for computing head pressure?
2. A water tower 130 feet high would exert how much water pressure?
3. In calculating back pressure, how many feet should you figure to the floor?
4. How much of a psi loss would there be to the sixth floor of a building?
5. What two items must be considered when computing the rate of discharge?
6. Why is the constant 29.7 used in computing the rate of discharge?
7. What is the formula for computing rate of discharge?
8. What would be the rate of discharge from a 1¾-inch tip with 36-pounds nozzle pressure?
9. How does the formula for computing rate of discharge from an open hose butt differ from the formula used for nozzle tips?
10. What is friction loss?
11. If the amount of water flowing through a hose line is doubled what effect will it have on the friction loss?
12. If the pumper shows 152 pounds discharge pressure and the nozzle has 61 pounds of pressure on it, what would be the friction loss?
13. What would be the friction loss per 100 feet of 2½-inch hose with 300 gpm flowing?
14. When the pump operator's guide plate is used to determine pressure required, the numbers to the right of the heavy zigzag line indicate that the changeover valve should be in what position?
15. What governs the height to which water can be drafted?
16. What would be required to lift (draft) water to a height of 33.9 feet at sea level?
17. A pump which is in good condition and well maintained could be expected to lift water to about what height?

4-2. Prefire Plans

Fire departments are organized to protect life and property from fire within the areas they service. Common sense dictates that you must analyze your problems intelligently to do an efficient and effective job. If fires continue to occur, and every firefighter knows that they *will*, then the best defense against the problems they create is to plan to meet them in an organized way. Your fire defenses should be so organized that you can go out and prevent as many fires as possible from occurring, while at the same time be prepared to fight, in an organized way, those you cannot prevent.

In this situation, you should be somewhat like the coach of a successful and winning athletic team. Athletic teams make plans for meeting each team on their schedule, devising methods of offense and defense to meet the particular threats which their opponent's previous games teach them to expect. What would you think of the athletic coach who failed to preplan for his team's next big contest; or one who didn't make use of his scouts; or worse yet, one who did not make use of the information his scouts have or can provide?

218. State the purpose of and requirements for prefire plans, and tell what information is included on prefire plans.

Air Force Regulation 92-1 sets the basic requirements for prefire planning. These requirements indicate the responses which must be planned for, i.e., each mission assigned aircraft; selected transient aircraft; mission essential facilities; missile sites and rocket pads; deluge or sprinkler-equipped facilities. Facilities that present a unique fire-protection problem (regardless of their occupancy) such as schools, clubs, and multi-story facilities require prefire planning along with other facilities designated by the fire chief.

Building Prefire Plans. All prefire plans are prepared on Air Force Form 1028, PRE-FIRE PLAN. Plans are prepared to explain procedures and geographically important information required during fire-suppression operations. Building prefire plans are carried on the assistant fire chief's vehicle and each first-run pumper. Aircraft prefire plans are carried on each fire chief's and assistant fire chief's vehicle. Copies of each prefire plan (building and aircraft) are maintained in the fire alarm communications center. AF Form 1028 is reviewed at least anually and is updated as required.

The first matter to be considered in any prefire planning is the specific risk that might be involved for each physical situation. This includes the streets, roads, and alleys between the fire station and the scene of the fire; also the location of the water supply and the volume and pressure available. The matter of exposure is also important. In other words, the first consideration in preplanning should be to recognize the specific problems involved when a fire occurs in a given building on your installation. The second is the question of availability of equipment. This means the particular kind of apparatus and vehicles your installation has for firefighting. This involves the mechanical and motorized equipment which is at your disposal. The third and final factor is the personnel available. Here is where the effect of good training will make itself felt.

Each of these aspects of prefire planning is more flexible and capable of adjustment or improvement, within certain limits, than the one preceding it. The physical situation is capable of little or no change. Under most circumstances, you must take your installation and the buildings just about as you find them. Very little can be done with this aspect of prefire planning, except in long-range programs involving improvements in water supply or hydrant locations, improvements in streets and traffic control, or condemnation of hazardous structures. The physical situation on your base is fairly well laid out for you. For practical purposes, you must almost always take this element as you find it and work out plans to meet the situation.

Next, you should consider the equipment you have available. If you have only one 500-gpm pumper, all your plans must be based on how to use it most efficiently. What fact can better demonstrate the need for improvements in your fire defenses? If your base water supply is adequate but your hydrant pressures are low, how better can you demonstrate the need for larger or additional pumpers than by showing the serious inadequacy of your one 500-gpm pumper in combating a fire?

This phase of prefire planning permits more effective accomplishment because you can usually improve prefire planning by demonstrating the need for certain equipment. It isn't enough to just say that you need equipment; the need should be demonstrated. The *need* without the *why* is the same as a conclusion without the reason.

The final phase of prefire planning pertains to personnel. Here, the only limits are intelligent planning and training. It is possible for you to do nothing but just sit and wait for the alarm. Or you can materially help improve your defenses by planning, educating, and training. What is the value of knowing all about aerial ladders or fire boats and not having them in your department? Why be fully informed about intricate hose evolutions and pumping pressures and then not adapt them to your particular problems? This type of information is worthwhile, but it won't help you combat a fire on your installation unless it can be applied to the specific situation you have at hand.

The Air Force Form 1028 serves two functions. First, it enables you to become familiar with every building on the installation. It shows the location, construction, and basic floor plan of specific buildings. From this information, you can get a definite idea of what to expect in the event of fire, and you can formulate definite tactics. This means that the operation will be quicker and safer, and that better results can be achieved because the "unexpected" has been anticipated. Second, it shows the fastest and safest route from the station to the building. Each prefire plan should contain the following basic information:

- Data on life hazards in each building, including where people sleep; the location of doors, windows, stairways, and fire escapes; and an outline of the most logical means of rescue.
- Information on interior and exterior exposures and how best to protect them, high-value storage, the placement of fire streams, and similar factors. Distances involved should be indicated.
- Consideration of special building or facility hazards, such as the location of flammable stores, hazardous operations, and the area most likely to be the origin of fire.
- The location of hydrants or other water sources, indicating the amount of water available and the pressure; also, the necessary lengths of ladders and their proper placement to reach required areas.
- The type and details of construction important to firefighting, such as false ceilings and advantageous areas for ventilation.
- The best approaches to the buildings, apparatus that will respond, most advantageous hose-laying procedures, and placement of streams.
- The cutting-off of utilities, including electric power and gas, indicating how and by whom it is to be done.
- The effect of seasonal changes on the accessibility to a building and the response time.
- Installed fire protection or detection systems, including locations and procedures for connecting pumpers to installed extinguishing systems.

All of the items on prefire plans are subject to some change; therefore, you must be on the lookout for any changes that may require you to reevaluate, modify, and alter existing prefire plans. For example, water mains may be relocated or temporarily turned off, streets may be closed for repair, and gas and electric cutoffs might be in different locations. Even the construction and location of a structure may be changed. Make sure that Civil Engineering notifies you of all activities that might affect your prefire plans.

Do not forget about the provisions of mutual aid. In an extreme emergency, you may need additional help from your neighboring community. In other instances, you may be able to give aid in return. Commanders are authorized to act as agents of the Secretary of the Air Force and to enter into an agreement with any fire organization. Mutual aid equipment and personnel play an important part in all types of emergency plans.

Exercises (218):

1. Why are prefire plans prepared for selected buildings?

2. Where would you go to locate a copy of the prefire plan for a specific building?

3. How often should each prefire plan be reviewed and updated?

4. You are to prepare a prefire plan on a specific building. What is the first matter that you must consider in preparing your prefire plan?

5. After you have recognized the specific problems involved with the building you are preplanning, what two factors must you consider and why must these factors be considered?

6. Why should you include data on life hazards on your prefire plan?

7. What information on interior and/or exterior exposures should you have on your prefire plan?

8. As you prepare your prefire plan, what information concerning water supply and ladders should you include?

9. Along with showing special features such as false ceilings and the type and details of construction, you should also indicate areas that will be most advantageous for ______ .

10. What information concerning utilities should you include on your prefire plan?

11. How should you be kept abreast of changes that may affect the prefire plans?

219. Tell what factors are considered in preparing aircraft prefire plans, and explain the importance of given factors.

Aircraft Prefire Planning. There are few areas of fire protection that demand more effort than that of aircraft prefire planning. However, the formulation of plans for this portion of fire protection is very complex and involved. You can make a fairly accurate prediction of the conditions that will exist in combating a burning building, but more flexibility is needed in prefire planning for aircraft, because more factors are involved.

For example, in structural prefire planning, you are fairly sure that Building 329 will always be located at the corner of Kelly Avenue and N Street. The floor plan of this building is not subject to frequent change. Once the best route from the station to Building 329 has been determined, it will normally remain unchanged. In fact, in structural prefire planning, there are many such known and unchanging factors. Aircraft prefire planning is not that simple. For example, you cannot determine the exact location of the crash. You can make general plans as to the likely crash areas, but even these general plans must be flexible. This does not make aircraft prefire planning any less important. In fact, aircraft incident planning is possibly even more important, because of the vast number of possibilities and complex situations.

This section cannot be used as an exact blueprint for aircraft prefire planning, because of the many variables involved, but many of the problems you must consider will be discussed. The location, mission, climate, and terrain of your base are important factors in this type of planning. Because these factors differ at each Air Force installation, we shall limit our discussion to the three factors that are common to most crash situations:

- The aircraft.
- Equipment.
- Personnel.

A careful evaluation of these three elements will help you determine the best course of action for any aircraft emergency.

The aircraft. Hours of planning may save only a second or two in reaching the scene of the crash. Weeks of planning may save only a minute in controlling a blaze or removing a victim, but in fire protection, *time is precious*! A split second may save a life. Knowledge of the aircraft may enable you to save time, thus protecting the most important thing in the Air Force – human life. Think about it another way. Lives may be lost if you and your crews are not well-versed on every step in a crash and rescue operation. You cannot afford to gamble; every member of your department should have a complete knowledge of the fire protection and rescue procedure for each type of aircraft.

The following questions should help you start your aircraft prefire plans. As you read these, you will think of other important questions. When you do, write them down and resolve them also.

For what type of aircraft should you plan? Your plans must include each type of mission-assigned aircraft. Also plan for mission support aircraft and transient aircraft that land and takeoff (including touch-and-go landings) from the installation an average of seven times a week during any three consecutive months.

How many people are on each aircraft? The safety of each individual on the aircraft is your first concern; therefore, you should formulate your plans around the number of people to be rescued. Vital information, such as the number of people actually on board each aircraft, is of concern for normal flights as well as during emergencies. Each member of the fire protection squad should also know how many occupants each type of aircraft will accommodate, so that he can anticipate his role in rescue operations.

What is the proper firefighting and rescue procedure for each type of aircraft? An entire course could be devoted to rescue procedures, but that is not necessary, since there are many sources of information open to you in this area. As a fire protection specialist or supervisor, your duty is to make sure that all rescue information is available, so that all of your subordinates will be well-versed on the proper rescue procedures for each type of aircraft. One of the best sources for this information is the aircraft itself. There are also directives, such as TO 00-105E-9, which will provide the characteristics of and information about a particular aircraft that must be included in the prefire plans. The predesignated rescuemen's duties must be included on the AF Form 1028.

How much fuel is the aircraft carrying? You will want to know the amount of fuel each type of aircraft can carry – more important, you will want to know the actual amount on board. This type of information may save lives and thousands of dollars.

When and where is the aircraft most likely to experience difficulty? You should make sure that each member of your crew knows the weaknesses of each type of aircraft, so that he can anticipate the most likely time and place of an emergency. For example, some aircraft are known to have critical landing speeds, while some have more difficulty during takeoff. What kind of emergency is the aircraft experiencing? The type of emergency will determine where you can best locate your crash equipment. Is the aircraft carrying weapons? You and your crews should understand the type and character of weapons that aircraft carry. Each member should be well-versed in the emergency procedures for the many different types of weapons and their locations on the aircraft.

Many of these questions require that you establish and use a rapid means of communication. The control tower and/or fire alarm communications center personnel should relay this pertinent information as soon as they receive it. You must use the fastest possible means of communication to relay the information to each crew.

The preceding questions do not make up a complete list, but they should assist you in starting your prefire plans. Remember, you have an obligation to become familiar with as much information as possible, concerning all types of aerospace vehicles.

Equipment. You should select a predetermined location for each piece of equipment, including rescue and resupply vehicles. As you consider various uses and positions for equipment, you can establish procedures for acquiring additional equipment. Some of these points are discussed in the following paragraphs.

Changing the position of your crash equipment may be necessary several times during a normal operational day. The weather, terrain, runway condition, and amount of equipment available will have a bearing on equipment location. The wind, for example, may change direction and require you to relocate all of your standby crash equipment. The speed at which the aircraft touches down and its stopping distance will also have a bearing on the location of your equipment. With these and many other factors, you can see that placement of equipment is a very complex problem. What is the answer? No one can reduce it to a formula, and no one can be sure that the best location has been selected. Carefully planning for all possible situations will assist you in choosing the most favorable location for your equipment when an actual crash occurs.

You know from your previous studies or personal experience that all fire protection equipment can be brought into service during an extreme emergency. Consider the possible uses of each piece of structural equipment and coordinate with other fire protection personnel, so that you can depend on the equipment being available when it is needed. Also, make sure that all possible uses for crash equipment have been considered in structural prefire planning.

Fire departments often agree to lend each other equipment or men in an emergency. This equipment may be used to "cover in" at a vacant station or to supply your crews with extinguishing agents. On occasion, you may need to use this equipment to combat an aircraft fire. Make sure that the equipment on loan is of the type that can be used for as many different purposes as possible.

In addition to fire protection equipment, there is the possibility of using other types of equipment on the installation. There are times when heavy equipment, such as wreckers, may save a life. Flatbed trucks can be used to transport foam, and tankers can be used to carry water to the scene of the crash. Use this type of equipment only when it can provide the fastest and most direct course of action. Your firefighting vehicles may need new supplies of foam and water after only 2 or 3 minutes of firefighting. You have an obligation to consider the possible uses of all base support equipment; then get the approval for its possible use, and coordinate with other organizations for that purpose. Make sure your crews are aware of the possibility of such use!

Consider the uses of other emergency equipment on the installation and in the area. Plan the location and application of emergency equipment and keep other emergency organizations informed. The base medics and security police will know what equipment they should provide at the scene of a crash if you keep them informed and if you coordinate with them during and after planning.

Personnel. Your final area of consideration in aircraft prefire planning is the use of personnel. The use of equipment and personnel go hand in hand, but each must be considered separately if your plans are to be successful. The following points should be considered during planning.

Earlier, recall procedures were explained, including the recall card. There is no need to have a special set of recall cards for each type of emergency; however, a master recall file should be established and used for all recall operations.

In aircraft prefire planning, as in other types of emergency plans, you should consider the resources available under the provisions of mutual aid, which we spoke of before as "lending" between fire departments. You may also wish to train some base personnel to work with the fire department. These auxiliary fire protection members could be trained to perform limited but important fire protection tasks in a very short time. Naturally, you must establish procedures to alert auxiliary personnel quickly.

Exercises (219):

1. You are preparing aircraft prefire plans for your base. What questions should you ask yourself about aircraft before you start preplanning?

2. For what types of aircraft must each base have prefire plans prepared?

3. Where should you go to get information on rescue procedures for your prefire plans?

4. As a rescueman, how will you know what your duties are on each different type of aircraft?

5. Knowing the weakness of each type of aircraft is of what value to you in your preparation of prefire plans?

6. What factors must you take into consideration in selecting an emergency standby position for each vehicle?

7. Besides the emergency vehicles and/or equipment, what other equipment (if any) should you plan on using for crash operations?

8. Other than the personnel on duty, what sources of manpower can you plan on using in your prefire planning?

220. Indicate whether given statements concerning missile site and rocket launch pad prefire planning are correct. If a statement is invalid, correct it.

Missile/Site and Rocket Pad Prefire Planning. Fire protection personnel operating at missile and space vehicle test or launch sites are faced with hazardous situations, unlike those encountered at other Air Force installations. The liquid or solid propellants used in missile engines possess characteristics which necessitate the use of specially developed but recognized procedures for their safe storage, handling, or disposal. Fire prevention procedures and firefighting techniques used for these differ from those used for conventional fuels. To provide maximum protection to life and property, you should understand the particular hazards involved.

The importance of careful preplanning of firefighting operations at missile sites cannot be overemphasized. No feature of the firefighting program can do more to insure effective use of men and equipment under normal and emergency conditions than a review and analysis of anticipated problems before emergencies arise. Elements of preplanning that should be covered are:

- Number, type, configuration, and operation of missiles or space vehicles and the related launch facilities.
- The layout of the launch site, including all access roads, terrain features, and water supplies; and the number, type, and location of support facilities.
- Location and configuration of the various propellant storage areas, and the nature of stored materials. Include the designation of the most effective and safe extinguishing agents for each of the particular propellants.
- Severe health hazards presented by the fuels, oxidizers, and other chemicals; and additives to fuels or coolant water. In addition to their fire and explosion hazards, these may require special protective clothing, reduced or controlled exposure time, monitoring instruments, or other special procedures.

Plans should be developed beforehand for an actual test or launch and for each type of operation. These plans should specify the desired number and classification of personnel, the number and type of firefighting vehicles and other equipment required, the number and size of hoselines to be preconnected, and the nature and availability of other emergency services. Prearranged signals from the "pad" safety officer indicate the time at which all emergency vehicles are to be withdrawn to the fallback area. In test and launch operations, the immediate launch area is cleared, operating personnel withdraw to the blockhouse, and emergency personnel and equipment withdraw to fallback areas. Similarly, the pad safety officer indicates when and which of the emergency services are to be called into the area after the test or launch.

Exercises (220):
If one of the following statements is correct, mark it True; if it is False, correct it.

_____ 1. The firefighting techniques used at missile sites and rocket launch pads are the same as those used for combating conventional fuel fires.

_____ 2. The number and configuration of missiles should not be included in the prefire plan.

_____ 3. The layout of the launch site should include terrain features, water supplies, primary roads, and the number, type, and location of support facilities.

_____ 4. The designation of the most effective and safe extinguishing agents should be included along with the location and configuration of the various propellant storage sites on your prefire plans.

_____ 5. The health hazards presented by the various fuels, oxidizers, and other chemicals should also be included in your prefire plans.

_____ 6. Your prefire plans should include the signals to be given by the pad safety officer to indicate when all emergency vehicles are to be withdrawn to the fallback area.

_____ 7. Another entry in your prefire plan should be the signals given by the senior fire offical to indicate when and which of the emergency services are to be called into the area after a test or launch.

221. From a list of statements about natural cover prefire planning and predisaster plans identify the true statements and explain why the others are not correct.

Natural Cover Prefire Planning. Natural cover fires, like each of the other types of fires, present some unusual problems to the firefighter. The tremendous areas involved and the number of men needed to combat natural cover fires make it impossible to develop completely adequate prefire plans. Limited water supplies require specialized tactics and equipment. Handtools and manpower, rather than motorized vehicles, are the backbone of natural cover firefighting.

The most effective means of combating natural cover fires are initiated before the fire actually occurs, through the medium of law enforcement, restrictions, education, and elimination of hazards.

Size-up. The most important consideration in fighting a natural cover fire is to choose the proper point from which to begin the attack on it. The selection of this starting point must not be made haphazardly; it must be based upon a careful analysis of the present and future conditions of the fire as determined by fuel conditions, weather conditions, and terrain. The steps in the size-up of a natural cover fire are as follows:

- Determine the size of the fire.
- Check the wind direction.
- Find out what kind of fuel the fire is burning and toward what kind of fuel it is headed.
- See if there are any natural barriers nearby to help stop the fire, such as streams, roads, plowed fields, or burned-out areas.
- Locate the hotspots, where the fire is burning most fiercely, and estimate when and where it may jump or throw sparks into a new supply of fuel.
- Set up your personnel evacuation procedures.

Attack. The aim of the initial attack is to stop the spread of the fire as quickly as possible. If there are numerous spot fires ahead of the main blaze which may "take off," they will need first attention. Otherwise, as a general rule, the attack should begin at the point or points where the fire is spreading or will spread most rapidly under severe conditions. Such points should be found on the side of a hill adjacent to accumulations of highly flammable fuel, on the uphill side of the fire on a steep slope, or on the side of the fire which is being or will be driven by the prevailing wind.

Attacking a fire directly at its head is possible only when the fire is not advancing rapidly and when a large number of men are available. Working directly in front of a rapidly advancing fire is hazardous, and there is always the possibility that the fire may outflank control lines. It is much better, in such instances, to begin work at safe points on the flanks and work toward the head of the fire. All of these points must be considered in the size-up; carelessness will result in delaying extinguishment of the fire, increased loss, and possible injury to personnel.

Predisaster Planning. As a fire protection specialist or supervisor, you will have responsibilities other than those required for supervising firefighting operations. Some of these responsibilities consist of training and evaluating fire protection personnel. In addition, you are responsible for the safety and well-being of subordinate personnel. It is also your duty to protect the property, equipment, and personnel of the base. Moreover, fire protection personnel may be needed to aid neighboring communities and military installations. Unexpected acts of nature, such as earthquakes, tornadoes, and floods, may place unusual demands on your equipment and personnel. The fire department must stand ready to offer assistance when and where it can. Disasters can be classified into two groups: domestic disasters and military disasters (caused by the enemy or agents of the enemy).

Domestic disasters. This type of disaster includes all emergencies which the general public and civil emergency crews cannot handle. It is not feasible to attempt to formulate a concise predisaster plan for each type of domestic disaster because of the many variables involved, the large off-base area, and the limited amount of Air Force fire protection equipment available. However, consideration should be given to factors that are likely to be involved in each type of domestic disaster. The following list of domestic disasters has been included so that you can consider some of the elements involved in each:

- Explosions involving large areas.
- Floods.
- Earthquakes.
- Tornadoes.
- Hurricanes.

These domestic disaster preplans may well be the most difficult plans to develop.

In addition to assistance required in major disasters, the fire department may be called on to assist in other domestic emergencies such as the following:

- Drownings.
- Heart attacks.
- Household accidents.
- Transportation accidents.

The Air Force fire department is only one of the many organizations that are involved in these emergency procedures. Two of the others are the medical authorities and the police. The best predisaster plans can be developed only when the military and civilian fire departments, police departments, and medical authorities coordinate and prepare one master plan.

Military disasters. All military installations must be considered as possible targets, because the enemy knows that all installations can assist in retaliation. It is also reasonable to predict that highly concentrated areas of industry, population, and military installations will be likely targets. Some areas and installations are considered prime target areas, while others are considered less important. These estimates are being continually made and updated by Civil Defense and other Government agencies. Your military disaster plans should be designed around these estimates.

Every person has certain disaster responsibilities. They are (1) to survive and help others to survive, (2) to do everything possible to restore normal functions and operations on the base, and (3) to furnish aid and support to neighboring communities and installations. All of these responsibilities fall heavily on the fire department.

The fire department serves as a strong aid of the Civil Defense program. Along with Civil Defense and National Guard agencies, the base fire departments will fight fires, perform rescue operations, provide first aid to victims, and perform restoration operations. With these functions in mind, you can design your military disaster plans. As in domestic disasters, a large part of these plans will be unwritten. This does not mean that you can ignore disaster planning. You should visualize as many disaster situations as possible; then plan how to use your equipment and personnel to the best advantage in combating each problem.

Provisions must be made to integrate existing fire protection and rescue facilities into the disaster control program without disrupting normal fire protection operations. Fire protection organizations may be helped by auxiliary forces composed of base personnel. These auxiliary units should report to and operate with predesignated units of the regular fire protection organization.

Training programs should be established that will not interfere with the primary duty of the installation. Such programs should be attended by auxiliary fire protection personnel, along with regular fire department members.

Those prefire plans that you develop should be uniform in the use of symbols. The NFPA Handbook has a section on prefire plans and it recommends symbols to use on them. The use of one set of symbols not only makes it easier for you to understand all the prefire plans for your base but will enable all other firefighters to read them.

As you can tell, not all of your preplans will go on the AF Form 1028. Those preplans for disasters, and in most cases natural cover fires, will be a part of the Base Disaster Plan; none-the-less, they are prefire plans and it has taken a lot of work to develop them. Let's just hope that they never have to be used except for training.

Exercises (221):

Identify each true statement and explain why the others are false.

1. Because of the size of the areas involved and the number of personnel needed to combat natural cover fires, it is impossible to develop completely adequate prefire plans for them.

2. When you have evaluated all factors (such as natural barriers) on your prefire plan, you should include as a part of the plan the proper point from which to attack a fire.

3. A part of your natural cover prefire plan should be devoted to the procedures for personnel evacuation.

ALARM RESPONSE

STRUCTURAL

AREA	STATION NO. 1	STATION NO. 2	STATION NO. 3	CALL OFF-DUTY	CALL MUTUAL AID
A	750A 530B 0-11A	750A 1000 GAL TANKER	MOVE TO STATION NO	ON 2ND	ON 3RD
B	750A 530B	750A 1000 GAL TANKER	STANDBY	ON 2ND	ON 3RD
C	STANDBY	750A	750A 500 1000 GAL TANKER	ON 2ND	ON 3RD
OFF-BASE MUTUAL AID		750A	750A	CALL ON FIRST	

NOTE: ON 2ND ALARM, ALL APPARATUS WILL RESPOND EXCEPT THE R-2, 0-6, AND 0-11A ON ACTIVE RUNWAY

AIRCRAFT

LOCATION	STATION NO. 1	STATION NO. 2	STATION NO. 3	CALL OFF DUTY	SPECIAL CALLS
RAMP INCIDENTS	0-6 R-2 530B P-2 0-11A	STANDBY			
EMERGENCY STAND-BY	0-6 R-2 530B P-2 0-11A	1000 GAL TANKER			
CRASH ON-BASE OR IN TRAFFIC AREA	0-6 750A R-2 530B 2 0-11A S P-2	750A 0-11A 1000 GAL TANKER	1000 GAL TANKER	ON 2ND	
OFF BASE	R-2 530B 0-11A/B	0-11A 1000 GAL TANKER	750A (IF NEEDED)	ON REQUEST	NOTIFY STATE POLICE

NOTE: ON ALL ACTUAL FIRE OR CRASH INCIDENTS, CALL CHIEF AND ASST. CHIEF ON RADIO OR AT HOME AFTER DISPATCHING THE ASSIGNED APPARATUS. THEN NOTIFY SECURITY POLICE, BASE FIRE MARSHAL AND OFFICER OF THE DAY

Figure 4-3. Alarm response card.

4. The limited amount of Air Force fire protection equipment is the primary reason you would not attempt to formulate a concise predisaster plan for each type of domestic disaster.

5. The most effective predisaster plans are made when each organizational element (military and civilian) prepares its own seperate operational plans.

6. Military disaster plans should be designed around the estimates of total dollar value of the installation and number of personnel assigned.

7. Military disaster plans should provide for auxiliary forces (composed of base personnel) to report to, and operate with, predesignated units of the regular fire protection organization.

8. In drawing up prefire plans and/or predisaster plans, you should use a separate set of symbols for each so that personnel will be able to tell the difference between military and civilian designations.

9. All of your preplans will be put on AF Form 1028, PRE-FIRE PLAN.

222. Match priority designators with the appropriate facility and ascertain the validity of given statements pertaining to response cards, correcting those that are invalid.

Response Card. The objective of the response card is to aid in making a quick and safe response of adequate and properly manned fire equipment to fires in identified zones, areas, or locations. The practice of using response cards or the response-card system is a primary element of preplanning for fire response. A significant factor in determining the amount and type of equipment to respond to any area, building, etc., is the fire potential or exposure involved. Also, this system designates "cover-in" crews required to respond if the normally selected apparatus is already busy or out of commission. In addition to quick and coordinated response, the response cards also convey to the alarm center operator the information required to insure speedy and adequate support from other activities which he may have to alert. Figure 4-3 is an example of a response card for an installation with three fire stations.

Priority designators. Each building and operational area should be assigned a priority designation. The response priority, concentration of firefighting operations, and employment of vehicle and manpower assets should be predetermined in the event that simulataneous fires occur on your installation. Priority designators should be assigned with the following information in mind:

- Priority One should be assigned to each building, area, or facility that is essential to the mission and the loss of which would immediately and completely result in loss of mission capability. Multistoried hospitals should also carry a Priority One designator.
- Priority Two should be assigned to each building, area, or facility that is in direct support of the mission and the loss of which would seriously impair of result in prolonged reduction of mission capability. Facilities presenting high loss of life potential or exceptionally extensive losses to buildings or to their contents would be classified as Priority Two responses.
- Priority Three should be assigned to each building, area, or facility that is considered a primary installation, operational, or housing facility.
- Priority Four should be assigned to all remaining base services, recreational, and related facilities.

Recall of personnel. You may need to recall personnel to duty during an emergency. Recall procedures should be established with all types of emergencies in mind, because and type of emergency or disaster could require the assistance of all off-duty fire protection members. The use of recall cards will expedite the return of off-duty personnel. These cards are in the form of an index card and should contain only pertinent recall information.

You will wish to use the fastest method of contacting off-duty personnel. Often a "pyramid" system of notification is considered to be the best. Under this system, three or four key members are alerted; each one of these, in turn, alerts other members. This will insure that each person is alerted. When the pyramid system is used, each person must have a definite understanding of his responsibilities.

Exercises (222):

If one of the following statements is correct, mark it True. If a statement is invalid, correct it.

_____ 1. The practice of using response cards or the response-card system is a primary element of preplanning for fire response.

______ 2. The alarm operator should use the information on the response cards to insure speedy and adequate support from other activities that he may have to alert.

______ 3. Response priorities are assigned to prevent simutaneous fires on your base.

______ 4. The use of response cards will expedite the return of off-duty personnel.

______ 5. The "pyramid" system of notification is often considered the best method of contacting off-duty personell.

______ 6. Match each of the descriptions listed in column B with its correct priority designator in column A by writing the correct letter in the blank provided. No description may be used twice.

Column A

_(1) Priority One.
_(2) Priority Two.
_(3) Priority Three.
_(4) Priority Four.

Column B

a. Facilities presenting high loss-of-life potential or extensive losses to buildings or their contents are assigned to this priority.
b. The loss of these facilities, which are in direct support of the mission, would seriously impair or result in prolonged reduction of mission capability.
c. Base recreational and related facilities are assigned this priority.
d. The loss of these facilities would immediately and completely result in loss of mission capability.
e. Military family housing facilities are assigned this priority.
f. These areas or facilities are considered primary operational facilities.
g. Multistoried hospitals should carry this priority designator.

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CHAPTER 5

Fire Alarm and Communications Center

EACH ALARM CENTER operates differently. A few of the reasons for these differences in operation are: the mission of the base, the equipment in the alarm center, personnel assigned, the fire chief's requirements, and base regulations. This section contains material you will need to know to assure that you, in your alarm center, will be able to provide reliable and accurate information to responding crews.

To read a book about a job that requires practice to perform efficiently is like reading a book about the Morse code. You cannot expect to read the book and then pass a test for 50 words per minute. Only constant practice on the transmitter-receiver will make you able to send and receive "dit-dit-dit-dah-dah" rapidly and accurately. Practice and performance of duty in the alarm center is no exception. Reading and studying the alarm center operating instructions will inform you of what your duties are in the alarm center. However, until you have familiarized yourself with the placement, position, and operation of all the equipment you will be using and are able to operate by instant reaction, you cannot be an efficient alarm center operator.

A small alarm center may require a short training period in which to learn your duties and to become familiar with the associated equipment. Other alarm centers, because of the many receiving devices, complicated equipment, and mission of the installation, may require a much longer period of intensive study and strict supervision under the watchful eye of your tutor before you will be able to "go it alone."

5-1. Duties and Responsibilities

Your duties as a fire protection specialist are to save lives and property. To do this job, you must know as soon as possible where your services are needed. This is why you must know how the alarm center works and what is expected of the alarm center operator. Personnel assigned duties as alarm center operators should be only the best qualified individuals. These individuals should demonstrate their ability, proficiency, and mental and emotional stability prior to this assignment.

223. Identify personnel responsible for specific functions associated with the fire alarm and communication center and tell what equipment you may expect to find in the alarm center.

Duties and Responsibilities of the Operator. The very importance of an alarm and communications center dictate that only highly responsible personnel work in this section. The alarm center should not be staffed with "the sick-lame-and lazy" just to have something for them to do. However, handicapped personnel may be assigned as communications operators providing the fire chief certifies they are properly trained and capable of operating all equipment.

As part of their duties, the alarm center operators are responsible for, but not limited to, monitoring, receiving, and recording information from normal and emergency communication systems. They are also responsible for alerting firefighting personnel and support agencies, dispatching equipment, and informing personnel of location and nature of fires. They must also provide pertinent information on emergencies, as required, and maintain the fire station log. Last but not least, the alarm center operator must be able to read and maintain the various maps, charts, and status boards that are on display in the fire alarm center.

Operational procedures covering your duties and responsibilities are maintained in the alarm center. These instructions must always be kept current to insure there will be no delay in emergency notifications. Normally, the procedures are written to tell you what to do in a given situation. They should give you step-by-step instructions for every operation performed and identify the individuals to be contacted during emergencies.

Equipment in the Alarm Room. Besides telling you what to do in a given situation, procedures should also be written on how to operate, maintain, and test (if required) each item of equipment in the alarm center (and whom to notify in case of trouble). The following will give you an idea of some of the equipment you could expect to find in an alarm center. (The exact equipment will depend upon the requirements of the installation and are determined by the fire chief, subject to approval of the local CEM (Civil Engineering Material) Board.)

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Reserved Emergency Line Phone. Two or more lines from the base communications and telephone exchange (on a rotary system) to the fire alarm center are reserved exclusively for the transmission of emergency fire alarms. The number 117 has been adopted throughout the Air Force as the standard number for fire reporting purposes. A dual fire reporting capability must be provided when on-base or immediately off-base military family housing is serviced by a commerical telephone exchange.

Operational Crash Alarm. There must be a primary telephone crash alarm, with receiving and transmitting capability, between base operations, control tower, medical center and the fire-alarm center. Provisions are also made for a secondary crash telephone circuit between base operations and other supporting activities (such as security police, civil engineering, explosive ordnance disposal). These systems should be restricted in the number of activities connected to avoid system saturation, interference, and delay.

Installed System Alarm Transmission. All installed systems transmit an alarm to the fire alarm center. Radio transmitting and receiving equipment or telephone-type circuits may be used. When telephone-type circuits are used, the terminal blocks in the frame rooms should be tagged at each end and identified to keep maintenance workers from interrupting service.

Administrative telephone. All fire station and related activity locations must have adequate telephone facilities to permit effective conduct of normal administrative business.

Sounding devices and public address facilities. These facilities must be adequate to assure notification and voice communication throughout all areas of each fire station. They are controlled from the fire alarm center.

Fire crash/nontactical radio net. An effective two-way fire crash radio net is required at each installation. Transceivers on this frequency are limited to fire stations, fire vehicles, explosive ordnance disposal (EOD), control tower, and the base civil engineer. The master control for commanding the Fire Crash/Explosive Ordnance Disposal network is located in the fire alarm communications center and is connected to an automatic-start emergency generator source.

Voice recorder. A voice recorder is interconnected to all central alarm center emergency voice communication systems to record all emergency information for later use.

As you can tell from the equipment listed, the responsibilities of the alarm center operator are wide in scope. The use of various equipment items will be discussed shortly. Just remember this—It is your responsibility as an alarm center operator to know the operation of all the equipment in your alarm center and how to properly use it.

Exercises (223):

1. You have completed your training of a newly hired handicapped individual and are certain that he is capable of operating the fire alarm center by himself. To whom must you go to have the proper certification made?

2. Who is responsible for maintaining the maps and charts in the fire alarm center?

3. A new fire station is being built at your base which will house the central fire alarm and communication center. Who will determine the equipment requirements for the new alarm center, and what is the basis for these requirements?

4. Your base has an off-base military family housing area serviced by a commerical telephone exchange; what provisions for fire reporting must be made?

5. Base operations, control tower, medical center, and the firealarm center are connected by what type of telephone hook-up?

6. When telephone-type circuits are used, the terminal blocks in the frame rooms should be tagged at each end and identified to keep maintenance workers from interrupting service for what system?

7. What facilities are used for voice communications and notification throughout all areas of the fire station?

8. What system in the alarm center has transceivers which are limited to fire stations, fire vehicles, explosive ordance disposal, control tower, and the base civil engineer?

9. What equipment would you use two days after a fire to learn exactly what was said over 117 when the fire was reported?

224. Tell whom you should notify (and when) if you have advance warning of an emergency.

From time-to-time, you may have advance notification of an emergency. In most cases, these advance notifications will be in the form of inbound aircraft with problems. There will also be times when other crews can be alerted for possible response such as for mutual aid runs or natural cover fires.

When these advance notifications are given you should immediately notify the assistant chief on duty and relay the information you have received. The assistant chief can then make the necessary decisions on action to be taken. DON'T wait until the last minute and then activate the station sounding system.

Let's say the command post calls and tells you that there will be a flight of 26 C-130s inbound in an hour and a half. The aircraft are coming from a base in Florida, due to hurricane "Bobbie" weather, and most of the aircraft will be low on fuel when they arrive over your base.

As soon as you confirm (read-back) the information with command post, you notify the Assistant Chief. With this information, the assistant chief can plan the course of action. It might be getting close to chow time and the regular meal time may have to be changed so the firefighters can still get a hot meal. There may even be justification for recalling the off duty shift. There are any number of things to consider and the more notification there is, the smoother the operation will run.

You will also want to inform all of the necessary supporting agencies of the situation and make any necessary special requests. For example, a standby mechanic may be needed in the station, or you may want to get transportation for additional foam and/or auxiliary firefighters. If these plans aren't made in advance, there may not be time later on. These support activities should be notified at the earliest possible time.

In the case of a mutual aid run, you would want to know where and when what equipment would be needed and to whom the responding crew(s) should report. Also get the name and phone number of the person making the request so the assistant chief can call them back for any additional information or instructions that may be needed.

Always be sure to check the operating instructions to see if there is guidance for the situation you are confronted with. If there isn't, then request the assistant chief to guide you.

Exercises (224):

1. When should you inform personnel that you have advance notification of an emergency?

2. Whom should you notify first?

3. Which supporting activities should be notified and for what reason?

4. How can you determine which support agencies to notify?

225. State how information from normal and emergency communications systems is monitored, received and recorded.

Monitoring. The keys to effectively monitoring the communications systems are attentiveness and knowledge of the systems. These are two of the reasons why alarm center operators are not allowed to sleep on duty and the center must be manned twenty-four hours a day.

Attentiveness. The alarm center operators must always be attentive to their equipment and surroundings. Reading magazines or books is discouraged because some people become so involved with what they are doing they forget to do their job; the same holds true for watching TV. A radio transmission has been missed more than once because the alarm center operator had his nose stuck in a book.

The alarm center should never be left unattended. If you must go to the restroom, have someone stand by for you, even if the restroom is just a few feet away. The few seconds you are gone could result in a missed call or signal on one of the systems.

Knowledge of systems. Your knowledge of the various systems will enable you to translate the message sent you by code into meaningful words and indicate the action that needs to be taken. If you don't know what the various codes mean, you could very well miss a fire call—or you could send the entire shift out on a power failure.

Receiving and Recording Calls. Receiving and recording fire alarms may be a simple operation, or it may be a patience-trying ordeal when you are trying to gather important information from a hysterical person over the telephone. In either situation, accuracy is of utmost importance, even above speed. The least effect that an inaccurate alarm reporting or recording could have would be to cause embarassment to the fire department. There is no limit to the total effect an inaccurate report could have on the base you are assigned to protect.

Probably the best way to insure that you issue the proper information to responding crews is to have, in your alarm center, a way of recording alarm information similar to that shown in figure 5-1. This is normally referred to as a recording board. It may be glass, plastic, or some other material easily written upon and erased. The surface should be sufficiently large (approximately 8 inches by 12 inches) to hold all the information, yet not be cumbersone. It is better to have the board fastened permanently on

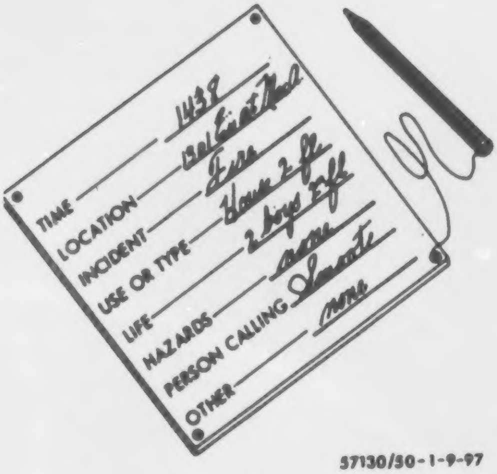

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Figure 5-1. Recording board.

the alarm center desk to prevent misplacing it. If transparent material is used, then a sheet of paper or white-faced poster board should be placed beneath it. This makes for ease in writing and reading the messages you record. Prompting or "reminder" words may be printed on the surface of the board, or they may be printed on the white background material mentioned previously.

These prompting words are important. They remind you of what you must ask when an alarm is received; remind you a second time of what you must tell the responding crews; and remind you a third time of what you are to write in the Daily Activity Log. Two items, in addition to the recording board, are needed close by to record alarms. One is a supply of grease pencils, ready for immediate use in case one breaks while you are writing, and the other is a cloth to remove the writing from the board after the entries have been transferred to the station log.

The alarm center should also be stocked with a good supply of Air Force Form 1271, Routing / Call Memo. These forms should be used anytime a call is received and the person being called cannot answer the phone at the time of the call. The necessary information is entered on the form and the form is then given to the individual at the first opportunity.

Exercises (225):

1. The keys to effective monitoring of communications systems are ______ and ______.

2. Why is attentiveness so important to alarm center operators?

3. Why must you know the systems installed in the alarm center?

4. Why should you use a recording board when receiving an emergency call?

5. Information from the recording board is recorded where?

6. What should you do when an individual has a phone call and is not in the station to take the call?

226. State the significance and the means of getting information for the entries on the recording board.

Information about the location and nature of the alarm is very important to the responding crews. Prompting words which you should have on your recording board include: time, location, incident, use or type, life hazards, the caller, and other pertinent information. Information on why these subjects are important to responding crews is covered in the following paragraphs.

Time. This should be an automatic notation. Each alarm center has at least one clock. Just one glance, while picking up the telephone, and you will know the time. Record it. Time of the alarm is necessary for official reports to identify the time of day the incident occurred.

Location. Location is the most important, although sometimes the most difficult, information to get. Suppose, when receiving an alarm, all you get is the location of the emergency. You can at least dispatch your equipment. Where do you send your equipment when you do not know the location but you do know there is a fire? If you have never had the experience of a phone being slammed down after the hysterical words "My house is on fire!" you have been very fortunate.

It is a natural reaction for some people to become excited when they, their loved ones, or their possessions are endangered. Uncontrolled fire has always been a frightening sight, but it is even more so when it becomes personal. You, the alarm center operator, must be able to calm the caller sufficiently to gather as much of the needed information as possible. After some experience in the alarm center, you will get the knack of dealing with various types of "voices" and of using the best tone of voice yourself in order to get this information.

You are always polite when answering the telephone. To be considerate of others, you use such phrases as "Please hold the phone." In a state of shock or high excitement, though, many people will disregard a polite request, but they will obey the stern *order—"Don't hang up your phone!"* In many instances, a tone of authority has the ability to cause an excited person to get a better hold on his emotions. Some fire departments require the alarm center operator first to instruct the caller not to hang up the telephone; and, second, to speak clearly, "Fire department, do you wish to report a fire?" In this manner, the order not to hang up has been given before the caller has a chance to start talking; also, the order has had time to become effective.

Normally, a prompting term or phrase, similar to the one on your reporting board, will be sufficient to get the facts you need. However, there will be times when you will have to wring out the information you must know. Persons who can cause you problems are the highly emotional, argumentative, incoherent, or talkative. They do not listen to what you ask them, or they question the importance of what you want to know. They do not realize that they are keeping the trucks from responding. In most situations, your calm voice will assist in calming the caller.

Recording the location of the emergency on the recording board is a simple operation. An abbreviated form of writing is sufficient, since you know what it means. However, scribbled, illegible notes take time for you to decipher. They may be misinterpreted, resulting in wrong instructions. Therefore, meaningful abbreviations and legibility are necessary for rapid and accurate notations on the recording board.

Incident. As explained under "Location," if all you know is the location, at least the crews can start their response. But how much better if they know the whole story! What type of emergency exists? A tree down over power lines? A suicide attempt? A vehicle or train accident? Is it actually a fire to which they are responding?

How much information is given when one word is used? What do you think of when you hear "Tree," "Wreck," "Suicide," or "Fire"? Add one or two words to each and you have: "Tree—power lines," "Wreck—three vehicles;" "Suicide—roof;" "Fire—building." The groups of words tell much more than the single words, because previous experiences can fill in a considerable number of the words necessary for the complete message.

An aircraft accident can be described in one or two words, such as "Crash;" "Hydraulic warning light on;" "Barrier engagement;" "Landing—flat tire." Again, past experience fills in the empty spaces and the crews have something more with which to work than just the location. They have some idea of what they will face.

Use or type. In the example of "Fire—building," as explained under "Incident," a better identifying word for building would describe what the building is used for. For example, house, barracks, warehouse, hangar, commissary, or officer's open mess, etc., describe and explain the problem more fully.

The word "vehicle" gives the impression of automobiles or trucks; but, in reality, the word means any mode of transportation. The size and use of the vehicle is important to the firefighters because of the possible hazards involved. A truck could be a ½-ton pickup or a large, 18-wheel semitrailer rig towing a tandem trailer. Vehicles could be traveling empty or loaded, carrying hazardous or nonhazardous material, liquids, or solids. Buses are also vehicles, but the cargo is considerably different from that carried in a truck. It may be a school, transcontinental, or city bus; this will influence response procedure. "Automobile" may mean a taxicab as well as a family car.

Aircraft incidents are about the same in that they require specific information. A bomber is larger than a fighter, and the B-52 is quite different from the B-57 or B-66. Sometimes the aircraft model will change firefighting and rescue procedures. The B-52G model, incorporating the "wet-wing" fuel system, carries in the wing much more fuel than the earlier models could carry in tanks or cells.

With each succeeding term, one or two words can be added, and the responding crews will have a bigger and better picture of what they will encounter when they arrive at the scene.

Life. There is always the possibility of life being involved in any alarm. Houses and barracks are living quarters; warehouses, shops, and hangars are working areas; service clubs, open messes, and gymnasiums are recreational facilities; and automobiles, trains, buses, and aircraft are modes of personal transportation. People are associated with all of them.

If your crews know beforehand that life is endangered and how many lives are involved, they can better cope with the situation. If they do not know that people are involved, they can increase the danger to life by the method they use in attacking the emergency. You, as the alarm center operator, would not feel easy if you neglected to try to get this information from the caller and a death or an aggravated injury resulted. The crews you sent would not be happy in knowing that they were the cause of the victim's misfortune. You and your department would be subject to ridicule from the public and severe criticism from the Air Force.

Hazards. There is a certain amount of danger in every emergency response. The danger may be traffic problems, whipping hoselines, height, falling walls, heat, or other conditions. The hazards to be noted on the recording board are of the type involving materials that will react dangerously to the heat of the fire or that are incompatible with water or other extinguishing agents. Prefire plans should have all hazardous materials, processes, or conditions listed and located on the plan.

Transportation incidents cannot be preplanned, except for firefighting and rescue techniques already learned. The person reporting an incident should be questioned as to the type of vehicle, the load, and the hazards, if any. Whenever an aircraft declares an emergency, the pilot should inform the control tower of the number of persons on board, the amount of fuel remaining, the cause of the emergency, and possible hazardous cargo. This cargo may be nuclear devices, conventional explosives, or dangerous processing materials, such as acids.

You will be most valuable to the crews you send to an emergency if you get the information about the hazardous material or conditions before they find out the hard way. Once the crews know there is a particular hazard, they will be able to proceed with a safer plan of attack.

The Caller. Most people calling in an alarm do not always realize how important their names and addresses may be in the subsequent investigation of an emergency. They are often reluctant to reveal their names or other personal information. Since the person calling is usually one of the first persons to discover the fire, he may see events or conditions that existed at the start of the fire but which will cease to be visible before the arrival of the fire department.

Upon being asked about the fire, this person may be able to state the origin of the fire, report any suspicious activity, verify the time of the alarm, describe the spread of fire, and provide many other facts and observations. The Air Force also likes to give credit where credit is due by publicizing the caller's name in the base newspaper and in other news media.

Other. If all the terms that could be used on the recording board were to be listed, they would make a very long list indeed. Some of the terms can be used to describe all incidents; some can be used only for special situations. Most of the terms, however, would be useless because of the infrequency of need. Therefore, all other conditions unique to a particular emergency are grouped under this last prompting term, "Other."

A possible use of this space could be to warn of electrical wires which are down in the area of the incident, alternate routes to take because of blocked thoroughfares, weather warnings, or a variety of other circumstances.

You would fully appreciate the value of a recording board if another alarm were sounded before you had a chance to complete your work for the first alarm. The possibility of this happening is rather remote, but it does happen. Your mind can "forget" the first alarm while you record the second alarm; yet, all the information on the first alarm is at your fingertips on the recording board, ready to be relayed to your crews.

Exercises (226):

1. Why is it important to note the time an alarm is received?
2. What is the most important information to get when you receive an alarm?
3. In taking an emergency call, how could you cause an excited person to get a better hold on his emotions?
4. How should you note the location of an emergency on the recording board?
5. Why is it important for crews to know the nature of the emergency to which they are responding?
6. The notes you make for "use or type" on the recording board should serve what purpose?
7. What difference, if any, will your giving information on lives involved in an emergency make to responding crews?
8. What type of information should be noted under the "hazards" heading?
9. Why is it so important to get the name and address of the individual reporting a fire or other emergency?
10. Of what use would the word "other" be on a response board?

227. Briefly describe the manner in which personnel on duty should be informed of emergencies.

Informing Personnel of Emergencies. The manner in which information is given to personnel is almost as important as giving them the correct information. Let's suppose that the control tower has just notified you, via primary crash network, of an RF-4C landing on runway 23 in 14 minutes with a hydraulic failure and fire warning light on on number 1 engine. There are 2 "souls" on board with 1700 pounds of fuel; no ordnance or photoflash cartridges. An approach engagement will be made. So how do you pass this information on to the troops?

Night time. Let's say the time for this situation is 0126 hours. You can get everyone mad at you by activating the sounding system (house bells, crash horn or whatever) and then getting on the public address (PA) system and relaying the information. Like I said, everyone is mad–why? You didn't turn on the "bunkroom" lights. Another thing you forgot is to open the stall doors.

Now let's go back and do it right–OK. First thing you want to do is turn the lights on (you should have controls for both bunkroom and apparatus floor in the alarm center), then activate the sounding system (3 to 5 seconds should do it; any more than five seconds will drive them crazy). Now use the PA system to relay the information. When you activate the sounding system, it is a good idea to open the stall doors at the same time. Repeat the information and give another blast with the sounding system; this should make sure everyone is awake, knows what the emergency is and on the way to the vehicles. By now, the crews should be getting on the trucks and the station will be noisy. This is a good time to use the radio to notify any crews that may have been out of the station. Once all of the trucks are out of the station, repeat the information over the radio one more time.

Daytime. If your emergency comes in at, let's say, 1015 hours, you would change your tactics just a bit. First of all you shouldn't have to turn the bunkroom lights on and in most cases, you wouldn't open the doors. (Someone may be working around them and you wouldn't know it.) The best thing to do here is to start off using the PA system with something like "Attention in the station. Attention in the station, we have an inflight emergency." Now you can activate the sounding system and pass on the information. Normally the "Attention in the station" will start the troops toward their vehicles. It's best not to hit the sounding system first; that bell or horn going off all at once just scares-the-heck out of some people and really starts the adrenaline flowing.

The exact manner in which personnel are informed of emergencies will depend upon the procedures set forth by the fire chief, the physical layout of the alarm center, and the equipment installed in the alarm center. The procedures just presented are in use in some stations today and have proven to be very, very effective.

Exercises (227):

1. What is the first thing you should do in informing personnel about an emergency during normal sleeping hours?
2. Why do you repeat the information given over the public address system and activate the sounding system the second time?
3. When should the information on an emergency be given to the crews the third time?
4. In informing personnel of emergencies during normal daylight hours, what two things would you NOT do that are done at night?
5. The exact manner of informing personnel as to the location and nature of emergencies will be determined by whom?

228. Tell how to dispatch equipment for nonemergency conditions.

There is a very fine line between informing personnel of the location and nature of an emergency and dispatching the equipment. Since these two actions normally take place at the same time we will keep this discussion to nonemergency conditions. It is very doubtful that you would go through the routine of notifying the personnel only to end your message with "don't roll the trucks yet." If this were the case, you should revert back to "alerting firefighting personnel."

Nonemergency. Not all of your dispatching of equipment will be for emergencies. It would be safe to say that most of your dispatches will be for other than emergencies. Sending a crew out on standby or ramp patrol is just as much a part of your job as getting the crews out for an emergency. Normally you don't use the sounding system for nonemergency dispatching, but this will depend upon the local procedures. It is best NOT to use the sounding system except for emergencies. If the sounding system is used too much, the personnel will tend to disregard it to some degree, thereby causing a slight delay in getting to their vehicles.

It is best to have the crew chief of the vehicle(s) receive the information from the alarm center operator and the crew report to their vehicle. This is effectively done by using the PA system with a transmission such as "Sgt Schiend to the alarm room - Crash 4 crew mount-up." When Sgt Schiend contacts you, give him the information he needs and his crew should be on the vehicle when he gets to it.

If the troops are in bed, you wouldn't want to wake everyone up just to send one crew out. There should be a "runner" in the alarm center at night or someone assigned to answer a phone in or near the bunkroom. This second person should know where each crew chief sleeps. The information is given to the crew chief(s) and they, in turn, awaken each crew member. If there is an excessive delay in the crews getting out of the station using this method, then the sounding system should be used. It doesn't take long for the rest of the shift members to convince a "slow" crew to speed it up some. No one likes to be awakened when he doesn't have to be—always keep that in mind when you make night dispatches.

Once the vehicle is out of the station, you should repeat all the information, via radio. Not only does this give the information to the responding crew another time, but will also serve to inform any other crews that may be out of the station that still another vehicle is on a response. All crews out of the station should know the location of all other crews that are out of the station in case an emergency arises. This could prevent an accident or "near-miss," or prevent two vehicles from going to a location where there should only be one.

Exercises (228):

1. Why should the sounding system NOT be used for dispatching equipment for nonemergencies?

2. When SHOULD the sounding system be used to dispatch equipment for nonemergencies?

3. What purpose is served by repeating the information to a crew responding to a nonemergency, other than giving them the information another time?

229. Tell what radio equipment the fire department uses, and translate messages into the 10-code and the international phonetic alphabet.

To maintain contact with vehicles and personnel out of the station you will be using the fire crash network. The manner in which this network is used has a great deal to do with its effectiveness. Try to visualize the operation of your department WITHOUT radio equipment and you will better understand its importance.

Two-way Radios. The fire protection organization is required to maintain an effective two-way fire-crash communications network at each active Air Force base. The network may include the control tower, hospital and ambulance, security police, central disaster control, and others designated by local policy. The number of support activities should be as few as possible, yet sufficient to maintain the mission of the base.

The radio network is comprised of fixed, mobile, and portable units. There is one fixed command set, located in the fire department alarm center. If the department has more than one station, you will find auxiliary fixed units at each station. All other essential activities have auxiliary units at their central offices. All pieces of fire apparatus are equipped with both sending and receiving sets, called transceivers (short for transmitter-receiver). To speak or transmit over either the fixed or mobile radio, you, as an operator, merely depress a switch on the set or depress the microphone button and then speak. A green light indicates that the set is on; a red light comes on when you press the switch for talking (transmitting).

The advantages of having radio facilities are many. A list of the more important ones would include these:

a. Information can be transmitted while vehicles are responding to an incident.

b. Work, such as inspection, maintenance, and training, can be done away from the station; yet the vehicle and crew are still available for emergencies.

c. Vehicles on standby duty can be alerted for incidents at other points or can alert the fire department if an incident is observed.

Whenever a vehicle is away from the station, the radio must be monitored by the crew chief or a member designated by the crew chief. The set in the station must be monitored by a designated individual at all times.

To be effective in sending messages by two-way radio requires practice. It may be easy to understand a rapid-fire talker when he is standing in front of you; however, he may be completely garbled when heard through the radio in a firefighting vehicle. Speaking clearly, distinctly, and in a normal tone of voice, under most circumstances, will make it easy for your listener to understand your message.

There are a few points that people who talk over radio transmitters forget. These points apply to members of the fire department. Security is one point that should never be forgotten because there is no control as to who may listen in on radio transmissions. Your security briefings, lectures, and literature stress this point. Discussion of classified information must wait until only authorized people can hear it. Therefore, never send classified information over the radio.

The use of curse words or obscene language is forbidden over any transmitting device or public communications system. The Federal Communications Commission, a Governmental agency, polices radio transmissions. If the persons guilty of such acts are apprehended, they can be fined, imprisoned, or possibly both. Even though you are a member of the Air Force, you are not immune to court action by the FCC. In some cases, court martial action may be taken by the Air Force.

Limit your radio conversations to official business only. We said this is a radio network. Other support activities use their radios to conduct business, too. During disaster control exercises, for example, the disaster control team works in close cooperation with the security police, hospital, and fire department. In other words, the fire department is not the only one using the assigned frequency. For this reason, it is necessary to have strict discipline in the use of the radio. One of the most important steps toward good radio discipline is the rule: Use the radio only when it is necessary and for official business only. It is not a plaything. And—speaking of official business—speak in a business-like way. Slang and "jive talk" have no place in business conversation.

In your career in the fire service, you will probably see the "walkie-talkie" type of portable radio in use for various reasons. These sets can be used to direct operations from fairly distant points between members of the fire department, for air-to-ground operations, for temporary use in vehicles not equipped with radio, and for any other valid reason.

Fire department vehicles are assigned radio call signs consisting of a code word designating the type of unit, followed by numerical sequence identification. The numbers should be of reflective material and 24 inches in size affixed to all sides and top of the vehicle.

Radio terms and procedures. The terminology of radio differs from base to base. Yet, you will find some terms and expressions that are universal, and memorizing them will help you when you are called upon to monitor your radio. About the most common expression is "Roger," meaning "Message received and understood." Others are "Do you read me?", meaning "Do you understand me?" or "Am I coming in clear?" or "Is the radio clear enough to understand?" "Say again, I say again," and "That is correct" are self-explanatory. "Over" means "My transmission is complete and I expect an answer." "Out" means "The conversation is over—period." The use of "Over" and "Out" should never be together. The words "Affirmative" and "Negative" are used in lieu of "Yes" and "No," to make a more emphatic sounding answer, and one that will not be misunderstood. If you have to correct a statement say, "as you were," then repeat the statement correctly.

You will find a code used in radio transmissions that simplifies radio usage to a great extent. It is called the 10 code. The numeral 10 and another number, are paired. For example, 10-1 (spoken as "ten-one") means "Reception Poor," 10-4 ("ten-four") means the same as "Roger." these codes have universal use and standard meanings.

Air Force Regulation 92-1 directs the use of the following communication code during all radio transmissions.

10-1	Reception poor (cannot understand)
10-2	Reception good
10-3	Stop transmitting
10-4	Message received
10-5	Standby (operator busy)
10-6	Station clear
10-7	Out of service until ______ or for ______ minutes
10-8	In service
10-9	What is your location?
10-10	Return to normal operations
10-11	Flightline patrol
10-12	Readiness standby
10-13	Crash Alert Standby (emergency)
10-14	Arrived at scene or position
10-15	Repeat last message
10-16	Disregard last assignment
10-17	Maintain radio silence
10-18	Involved in accident
10-19	Return (or returning) to station
10-20	Finished with last assignment
10-21	Radio check
10-10-10	Standby-emergency transmission, all units.

The above codes are mandatory for all installations. Other codes may be added to meet the requirements of individual installations.

You must remember one other thing when you use the radio. The control tower operators may not know what you are talking about when you use the "10-code" with them. In this case, if they ask you to "say again" repeat your transmission "in plain English" and not code. Most times the control tower personnel are too busy to chase around looking for their copy of the code – give them a break.

Pronunciation is most important to good radio transmission. Misunderstood words could mean misunderstood orders. To be sure the message is clear, words are frequently spelled out by means of the international phonetic alphabet. Each letter of the alphabet is designated by a word. Learn these words and their accepted pronunciation for best radio understanding.

LETTER	WORD	PRONUNCIATION
A	ALFA	(Al fah)
B	BRAVO	(Brah voh)
C	CHARLIE	(Char lee)
D	DELTA	(Dell tah)
E	ECHO	(Eck oh)
F	FOXTROT	(Foks trot)
G	GOLF	(Golf)
H	HOTEL	(Ho tell)
I	INDIA	(In dee ah)
J	JULIET	(Jew lee ett)
K	KILO	(Key loh)
L	LIMA	(Lee mah)
M	MIKE	(Mike)
N	NOVEMBER	(No vem ber)
O	OSCAR	(Oss cah)
P	PAPA	(Pah pah)
Q	QUEBEC	(Key beck)
R	ROMEO	(Row me oh)
S	SIERRA	(See air rah)
T	TANGO	(Tang go)
U	UNIFORM	(You nee form)
V	VICTOR	(Vic tah)
W	WHISKY	(Wiss key)
X	X-RAY	(Ecks ray)
Y	YANKEE	(Yang kee)
Z	ZULU	(Zoo loo)

To transmit numbers, use the following standard pronunciation:

NUMERAL	SPOKEN AS
0	zero
1	wun
2	too
3	thu-ree
4	fo-wer
5	fi-yiv
6	six
7	seven
8	ate
9	niner

Here are two examples: The aircraft F-100 would be stated as "Foxtrot, wun-zero-zero." The C-47 would be "Charlie , fo-wer-seven." The phonetic transmission of "Type 0-5" would be "tango-yankee-papa-echo, zero-fi-yiv." Now, for practice, try spelling out loud your own name and serial number, using these words for letters and numbers.

Terminology, expressions, and pronunciations for radio communications are found in AFM 100-21, *Management and Use of USAF Communication Electronics.*

Exercises (229):

1. The radio network includes what three types of units?

2. What do we mean by the word "transceiver?"

3. When may you use a radio to send classified information?

4. What publication directs the use of the mandatory code used for fire protection?

5. When would a "three part" 10 code be used and what are the three part numbers?

6. Write the 10 codes for the following messages:

   a. Message received.

   b. What is your location?

   c. Return to normal operations.

   d. Crash alert standby (emergency).

   e. Repeat last message.

   f. Return to station.

7. Spell the word Boultier in the international phonetic alphabet (as in Boultier Street).

230. Tell how to relay pertinent information on emergencies.

Any information you receive that may influence an emergency response should be considered pertinent and should be relayed to the responding crews. The information from the recording board is a good example. (Except for the time and name of person making the call.) In some cases, the assistant chief may request the name of the caller if a question arises at the scene and information is needed from the caller. The time may be critical in case of a crash where explosives are involved, so this information is included in the relay transmissions.

Once the information has been given to all responding crews and they have "10-4ed" your transmission, keep your radio traffic at a minimum. Unnecessary radio traffic could cause an important transmission to be cut out or misunderstood. As additional information is received, relay it at once. If the control tower relays information via radio, check each vehicle to be sure the operater has received and understands the information.

You may receive some information about the emergency that the crews do not need, but you will need in filling out the paperwork later on. It is not necessary to relay this information unless it is specifically requested. If there is any doubt as to the value of the information, relay it. You cannot give the crews too much information but you can "short-change" them.

Exercises (230):

1. How do you decide what information is pertinent to an emergency?

2. What effect may unnecessary radio traffic have?

3. When should you relay pertinent information to the crews?

4. How should you treat information if you aren't sure about its value?

231. State whether specified entries should be made in fire station logs, which ones should be in red ink, and who certifies the accuracy of the logs.

The Daily Activity Log is the historical report of a fire department. This is true whether it is a one-truck department or a large department with 10 stations and 50 trucks. It is a record that lists the events that have taken place for a specific period of time for that department, usually 24 hours. Fire departments with more than one station have a log that is kept at each station in addition to the log at fire headquarters. The meaning of *log* as used here is similar to that of a ship's log, which lists the progress and events of that ship. It is also called a *log book*. The information that is recorded should include personnel duty assignments; vehicle movements; mechanical status of vehicles; responses to incidents; emergencies; false alarms; alarms received; alarms from automatic, manual, and sprinkler systems; training exercises; names of visitors; injuries to personnel; and any other information deemed necessary by the fire chief.

The log at fire headquarters, when there is more than one station, should reflect the activities of the entire fire department. This log is a permanent record and is prepared by hand entries in a bound, ledger-type book. Fire incidents and emergencies are entered in red ink. It is reviewed, approved and signed by the senior fire officer in charge at the close of each work shift. Each officer in charge of a subordinate station maintains a daily log of that station's activities.

Personnel Duty Assignments. At the beginning of each shift of duty, a roll call should be taken and the names of the persons present should be recorded in a log as present for duty. Those not present for duty should have the reason for their absence noted. These absences may include TDY, day off, sick call, leave, excused from duty, squadron detail, or similar reasons which are authorized excuses. Unauthorized absences, including AWOL, late, failure to report to place of duty, and similar reasons, should also be noted. The positions or duty assignments for each shift should be recorded. These may be changed for the next shift, due to vehicle deadlined, shortage of personnel, cross-manning, or other reasons. If, during the course of a shift, a member of that shift reports for duty after roll call, his or her name and the time of arrival should be logged. In the same manner, if a member should leave his or her place of duty, this also should be logged, with the time and reason for leaving. This record maintains control of personnel and allows for systematic reassignment when necessary. The log also includes a running account of the place of assignment of personnel. At times, a log may be used to justify an increase in personnel authorization, when the workload has been permanently enlarged and more personnel are needed in the department.

Movement and Mechanical Status of Vehicles. As important as personnel may be, the vehicles of any present-day fire department are equally important. If the whereabouts of the vehicles are not known at all times, the responses to alarms may be delayed or perhaps not made at all. It is the alarm center operator's responsibility to know how many vehicles there are available for runs, how many are in the maintenance shop, and to what location a truck has been sent. In other words, he should know where each and every truck is at all times during his tour of duty. Moreover, he should be able to determine the importance of previous assignments of crews and trucks in order to recall and reassign them in case of an emergency. These movements must be entered in the log with the "out" time and "in" time of the assignment. If the truck is declared to be out-of-service, the reason should be entered.

Fires, False Alarms, and Other Emergencies. There should be no question in your mind of the necessity for entering this type of information in the log. In the discussion concerning the recording boards, you learned the important points to be logged for an alarm. What do you do about an alarm received through a direct connection with the fire department involving sprinkler systems, automatic alarm systems, and pull boxes? These systems do not talk to you; however, you can get certain facts from them when they sound off. When a street box is pulled, you know the general locality by the code number assigned to that box. A sprinkler system on an automatic alarm system may be so small that the whole system is given one code number, or it may be so large that only a single section of a building is represented by a code number. If you can, imagine a response to the Pentagon, with the entire mammoth building–covering 34 acres–protected by an alarm system having but one code number! Millions of dollars in fire damage could result before the fire was actually located by the fire department.

As an alarm center operator, all you will be able to give the responding crews is the code number and the location of the alarm device that has been actuated. You will not know whether it is a malfunction, a water surge, some unscheduled maintenance, or the real thing. Only when the crews call in or return to the station and let you know the cause of the alarm will you be able to enter that information in the log. After responding crews report the nature of the emergency, you might have to enter in your log that it was a false alarm. False alarms are troublesome, expensive, and unnecessarily dangerous. Yet, you must send the crews, because you will not know whether a real emergency exists until the crews arrive at the location of the alarm. Many false alarms cannot be traced to the sender. If, however, as much information as possible is recorded in the log book on each false alarm, a pattern of activity may be detected. This information should be passed on to the proper authorities for further investigation.

Other emergencies are recorded in the log in the same manner as alarms: time, location, incident, and so forth. Whenever a call to the fire department comes in, the fire department is expected to respond. The call could be a drowning, electrical shock, heart attack, or any other possible incident not associated with firefighting. These calls are recorded in the log book, and the action taken on these calls is also noted. If the fire department has the required equipment and the specially trained personnel to handle these emergencies, it is the alarm center operator's duty to know and to dispatch the proper personnel and/or equipment. If, however, it is against the fire department's policy to respond on certain emergencies, the alarm center operator should know the correct agency to contact. He can then refer the caller to someone who can help or, after taking the information, relay that information to the correct agency. It is still your job to save lives and protect property, although it may seem to be stretching it a bit when you have to dispatch a $25,000 piece of equipment with five firefighters to rescue a cat in a tree.

Miscellaneous Entries. Among other items that should be logged are visitors, injuries to personnel, special exercises and training, and unusual incidents.

Visitors. The logging of visitors has unique value. Naturally, the times when the visitor or visitors arrive and depart are logged; the names of the visitors and the reason for the visit are also logged. If, as during Fire Prevention Week, school groups or other organizations are the visitors, it is quite sufficient to name the school, grade, troop, or other identifying remark. Some visitors are VIPs (very important persons). They may be there to visit the chief or some other individual. On most occasions, these people are there for purposes of inspection or for other official business. Greeting and logging visitors is one way of promoting good public relations with the rest of the base and with the surrounding area. These and other entries of fire prevention activities conducted throughout the year by the base fire department are an important source of information for records and reports.

Injuries. We must log injuries to personnel at the station or on an alarm. These entries should include witnesses, the cause of the injury, circumstances leading to the cause, and all other pertinent information. It is unwise to state the nature of the injury, especially if it is serious or internal, before consulting a competent medical authority. Enter the name of the medical attendant, and write his or her remarks *verbatim* and enclosed in quotation marks. The Ground Safety Office is interested in these injuries from the standpoint of prevention. The log entries contain fresh information from the witnesses and the injured person and, being a permanent record, can be read again without a change in words. It may be some time before the Ground Safety Office can send a representative to investigate the incident and make the necessary recommendations to prevent the incident from occurring again.

Special exercises. Special exercises, such as training drills, should be logged. This is a record of a part of the training the fire department is conducting to develop efficiency in firefighting. Tell the length of time per drill, the vehicles and crews participating, the type of drill, and the evaluation of the exercises. This information lets the fire chief and other responsible parties know how the time is spent, what training is accomplished, where training is needed, and who is being trained.

Unusual incidents. The determination as to what unusual incidents to enter in the log would not be difficult if all unusual incidents caused the type of damage that results from a high wind, tornado, blizzard, or earthquake. However, one might hesitate to enter in the log as an unusual incident the finding of a small child in the station at 0310 hours. The decision for entering such items as "unusual" in the log should be based on the local conditions. Does this type of condition occur often, and (very simply) is it noteworthy enough to be included in the log?

Exercises (231):

1. In the space provided to the left of each item, enter a "Y" for yes if the item should be entered in the station log, or an "N" for no if it need not be entered.
    a. ___ Inflight emergency on an F-15.
    b. ___ Mr. Platz cut his hand on a broken window in the kitchen and required 2 stitches.
    c. ___ Mrs. Oster called to tell Sgt Oster that their dog has pups. Sgt Oster on standby.
    d. ___ A signal from the sprinkler system in Hangar 1.
    e. ___ Mr. Charles Michael Assmann from HQ USAF in the station to see Chief Rachke.
2. Which of the entries listed above should be logged in red ink?
3. Who reviews, approves, and signs the daily log at subordinate stations?

232. Interpret the information on a grid map and identify symbols used on grip maps.

As a member of a fire protection organization, you must realize that the sooner the crew arrives at the scene of a fire, the better are the chances for personnel rescue and fire extinguishment. This is especially true when you are required to respond to such off-base emergencies as aircraft crashes, brush fires, forest fires, or structural fires. You must realize that someone's life or someone's property depends upon your ability to direct a crew to the scene (and the crew's ability to reach the scene) as soon as possible. In this section we will discuss briefly the typical maps you might use as a firefighter, and how to recognize objects by their relative symbols.

A map is a diagram drawn on a flat surface representing a part or all of the earth's surface. For our purpose, the map will show the surface which immediately surrounds our airbase. The primary purpose of a map is to help you to locate and reach any particular spot within the area covered by the map. When you are trying to locate a particular spot, there are two factors that you must first consider: (1) the direction and (2) the distance. To use a map, you must also know the relationship between the minimum distance which you will have to travel and the distance as measured on the map from one place to the other. That relationship is called a *scale*. A scale of 1 inch per mile would mean that 1 inch on the map would represent 1 mile distance on the ground. Two inches on the map would then be 2 miles as you would travel if there are no obstacles.

The distance to which your fire department will respond to emergencies is governed by local policy. The policy is usually determined by the location of the base, the terrain, and the location and size of the surrounding communities. Often these off-base areas are complex networks of roads and paths intermingled with fences, woods, fields, hills, rivers, lakes, towns, and communities. Therefore, before you can direct a crew to a given location in the shortest possible time, you must learn to read maps.

Signs and Symbols Used on Maps. The symbols on a chart or map usually are divided into topographical groups. The groups consist of topographic information necessary for a clear and accurate representation of the region. The groupings also contain information pertaining to navigation by air or to vehicle accessibility in terms of roads and terrain.

The signs and symbols on maps and charts must be learned; just as words, they should be associated with the objects they represent. In general, symbols resemble the objects they represent, and they vary in size with the scale of the map. Some of these map symbols are shown in figure 5-2. Topographic symbols may be divided into three groups: water, culture, and relief.

Water. Water features consist of streams, lakes, canals, swamps, etc., which are usually shown in shades of blue. Culture groups include towns, cities, roads, railroads, and other works of man; these are usually shown in black, but also may be in yellow or purple. Relief features show altitude variation by contour lines ranging from light purple (below sea level), to green (sea level), to shades of light brown to dark brown (above sea level and higher altitudes). Water features are recognizable by the blue (occasionally another color) which usually designates them. The signs and symbols that indicate culture are varied enough to require further discussion here.

Culture. Towns with a population of less than 1000 are indicated by a conventional black circle.

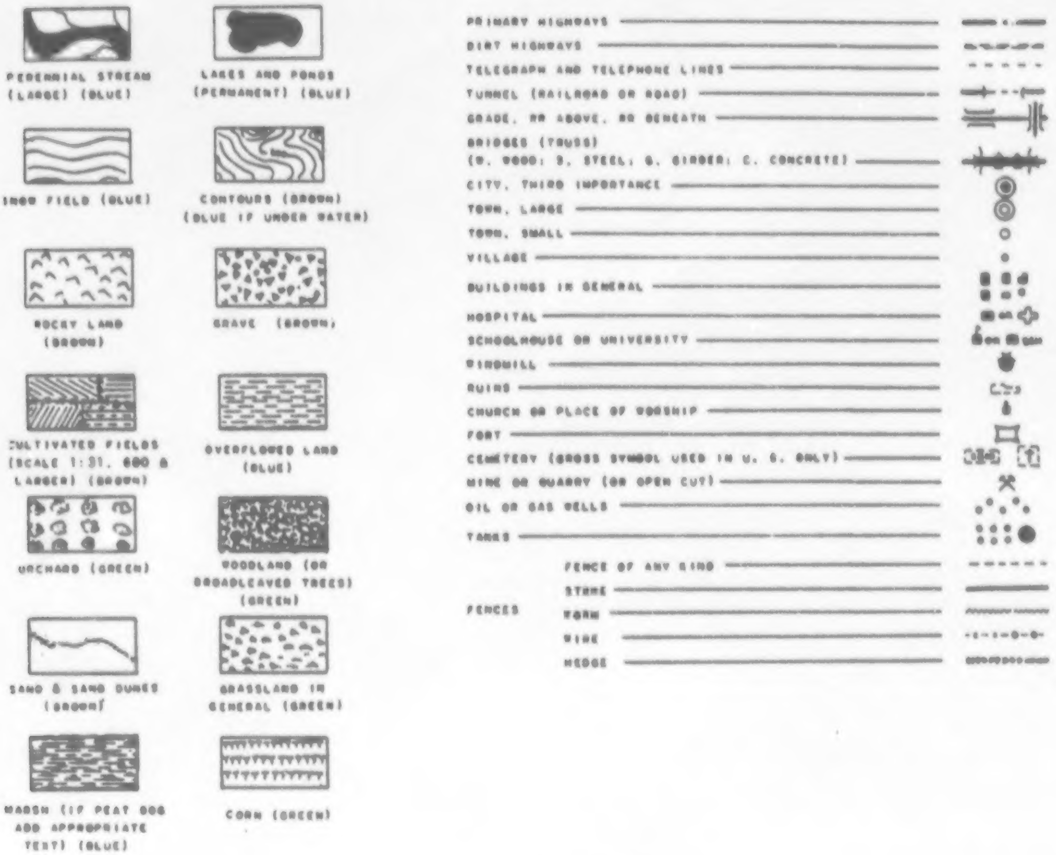

PERENNIAL STREAM (LARGE) (BLUE)
LAKES AND PONDS (PERMANENT) (BLUE)
SNOW FIELD (BLUE)
CONTOURS (BROWN) (BLUE IF UNDER WATER)
ROCKY LAND (BROWN)
GRAVE (BROWN)
CULTIVATED FIELDS (SCALE 1:31,680 & LARGER) (BROWN)
OVERFLOWED LAND (BLUE)
ORCHARD (GREEN)
WOODLAND (OR BROADLEAVED TREES) (GREEN)
SAND & SAND DUNES (BROWN)
GRASSLAND IN GENERAL (GREEN)
MARSH (IF PEAT BOG ADD APPROPRIATE TEXT) (BLUE)
CORN (GREEN)
PRIMARY HIGHWAYS
DIRT HIGHWAYS
TELEGRAPH AND TELEPHONE LINES
TUNNEL (RAILROAD OR ROAD)
GRADE, RR ABOVE, RR BENEATH
BRIDGES (TRUSS)
(W. WOOD; S. STEEL; G. GIRDER; C. CONCRETE)
CITY, THIRD IMPORTANCE
TOWN, LARGE
TOWN, SMALL
VILLAGE
BUILDINGS IN GENERAL
HOSPITAL
SCHOOLHOUSE OR UNIVERSITY
WINDMILL
RUINS
CHURCH OR PLACE OF WORSHIP
FORT
CEMETERY (CROSS SYMBOL USED IN U. S. ONLY)
MINE OR QUARRY (OR OPEN CUT)
OIL OR GAS WELLS
TANKS
FENCES
FENCE OF ANY KIND
STONE
WORM
WIRE
HEDGE

Figure 5-2. Map symbols.

Towns that have a population of between 1000 and 5000 are shown by a yellow square outlined in purple. The actual shapes of large cities may be shown in yellow, within a purple outline. Railroads are represented by fairly heavy black lines with crossties; electric railways (trolleys) are represented by lighter black lines with crossties at closer intervals. Single-track railroads are shown with single crossties; railroads with two or more tracks have the crossties in pairs. Even after a railroad has been abandoned or torn up, the old roadbed may hinder trucks responding to fires and crashes. When the railroad is no longer used, the old roadbed is indicated on the chart by a broken line with crossties. Tunnels, underpasses, and bridges are indicated. Close attention should be paid to bridges and underpasses; their weight and clearance limitations are especially important to trucks going to the scene of an emergency. Prominent highways are indicated by heavy purple lines; secondary highways are shown by lighter lines in purple; very poor roads are indicated by a broken purple line, which is the conventional symbol for a trail. "Prominent" highways and "secondary" highways must be understood as being only relative terms. In some thinly settled western districts, roads are so few that practically all are shown. In a situation such as this, a relatively poor road may be so prominent in its own vicinity that it is charted with a heavy line.

On the other hand, in the more thickly settled sections there may be so many roads that it is impossible to include all of the improved roads. The map treatment of highways, therefore, varies with the region. In each case, however, an attempt is made to show the distinctive road patterns as they would be seen from the air.

When possible, an aircraft is used to locate the crash and to guide crash trucks and convoys to the scene. It is important, then, where radio contact is used between ground vehicle and aircraft, for fire and rescue crews to have as much information as possible regarding the appearance of objects from the ground as contrasted with their appearance from the air. For example, a tall building will not appear to have height from an overhead position.

Race tracks are prominent landmarks, and whenever possible, their characteristic oval shapes are indicated in black. In congested areas, where the actual shape cannot be shown, the location is sometimes indicated by a heavy dot, and the words "race track" or the letters "R.T." are printed in the nearest open space, with an arrow leading to the dot.

Lookout towers in the State and National forests are located on the highest ground in the vicinity and are usually quite prominent. In some cases, they have been airmarked with a number. These numbers appear in vertical black figures adjacent to the symbols. Elevations of the ground at the towers are added in black italics. Forest ranger stations are shown by small symbols suggestive of the ranger station and its flag. A mine quarry is represented by a symbol of the pick and hammer of the miner. A coast guard station is indicated by a small black boat accompanied by the number with which it has been marked for identification from the air.

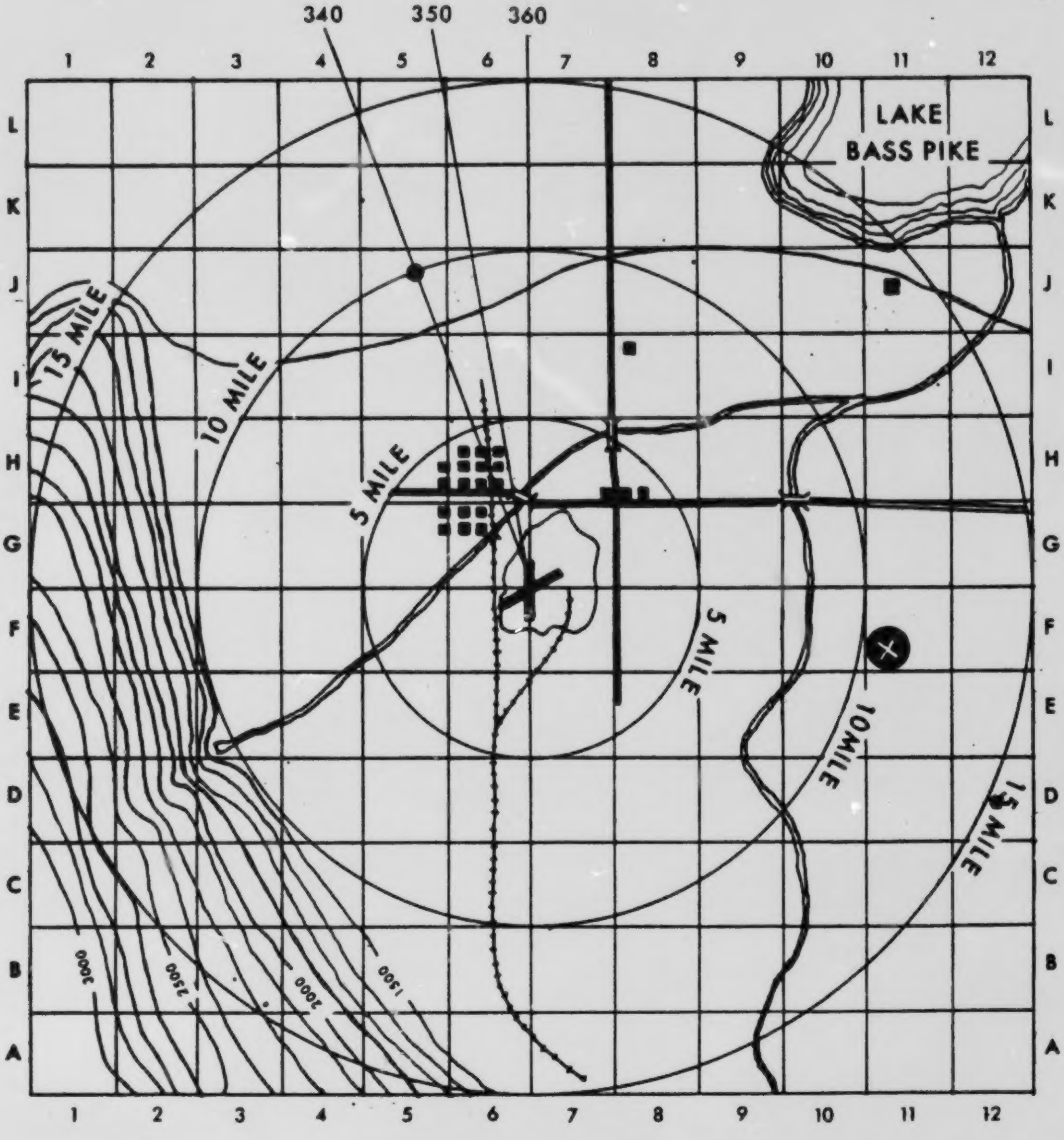
In addition to the foregoing, there are, in many localities, many unclassified distinctive landmarks which help us to identify a position. These are usually indicated on the sectional charts with a dot and a descriptive note. It should be understood that, even on the larger scale maps and charts, certain features must be exaggerated in size. For example, if a prominent highway is measured by a scale of statute miles on a sectional chart, the highway appears to be about an eighth of a mile in width. This exaggeration is necessary for the sake of clarity and emphasis. Again, in a narrow canyon, it may be necessary to show a stream with a railroad on one side and a highway on the other. On the ground, the three features may occupy a space no more than 175 feet in width; yet on the chart showing the three features as close together as possible, they seem to occupy more than a third of a mile, or about 2000 feet of width. If a long, narrow lake were actually reproduced, it would be a fine, single line. In order to preserve the shape of the lake, this line must be exaggerated in width enough to show a small area of blue tint between the two limiting shorelines of solid blue. Whenever possible, symbols are centered on their true locations and magnified only as much as may be necessary for a clear representation.

Relief. Elevation and unevenness of land surface can be shown on maps. Mountains, hills, valleys, and other variations in altitude are usually indicated by contour or relief lines of brown. Relief is also emphasized by a series of gradient tints, ranging from green at sea level to a dark brown above 9000 feet. On a few charts of the west, areas below sea level are indicated by a faint purple tint. Some prominent peaks or steep cliffs are also accentuated by shading, with elevations shown in black italic figures. Many other critical elevations, such as mountain passes and high points, are shown in the charts, with a dot to designate location. The elevations of many cities and towns are also shown.

A "contour line" represents an imaginary line on the ground, every point of which is at the same height above sea level. The varied curves of the contour show the ridges, valleys, canyons, bluffs, and other details. With a little practice you may read elevations and shapes from the contour lines—and do so with great accuracy.

A contour is also described as the intersection of an imaginary horizontal plane with the surface of the earth. One way of visualizing contours is to think of them as successive shorelines if the sea should rise to the levels indicated by the respective contours. The line of a sea coast is a contour; every point thereon has the same elevation (zero). Valleys sloping down to the shoreline are represented by a curve or indentation landward; ridges result in a curve which is seaward. Now if the sea should rise 1000 feet, the 1000-foot contour would become the shoreline, and the valleys would still be indicated by a curve toward the higher ground. If a cliff should rise almost vertically above the shoreline for 1000 feet, the 1000-foot contour would appear on the chart very close to the shore. When the terrain slopes gently upward from the coast, the 1000-foot contour is inland a considerable distance. Thus, contour lines that are far apart on the chart indicate a gentle slope; lines that are close together indicate a cliff. Crossed contours will occur in the case of an overhanging cliff. Where contours cross a stream, they bend toward the source of the stream (upstream), which is, of course, on higher ground. Where contours cross a ridge, the opposite is true, and they bend away from higher ground.

When firefighters respond to an off-base emergency, they must be aware of land elevations, because emergency water sources are frequently used to combat fire. This water is generally acquired by drafting from a lake, pond, river, or tank. As elevation increases, the atmospheric pressure decreases and, in turn, allows less drafting height. A pumper that is able to draft water to a maximum height of 18 feet at sea level would be unable to draft water over 15½ feet at an elevation of 5000 feet. The ability of the pumper to draft water decreases about one-half of a vertical foot per 1000 feet of elevation, with other conditions remaining the same. This illustrates one of the many reasons why it is important that you know how to read and apply contour lines.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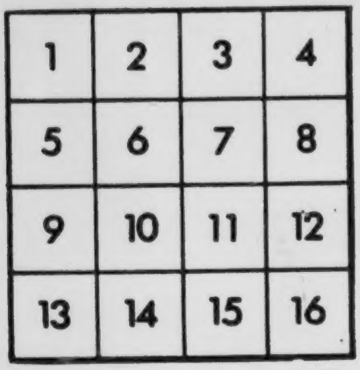
A
LAKE
BASS PIKE
15 MILE
10 MILE
5 MILE
5 MILE
10MILE
15 MILE
3000
2500
2000
1500
57.92

Figure 5-3. Grid map-block identification.

Grid Map-Block Identification. In the interest of establishing a standard procedure of reading grid coordinates, maps are numbered left to right at the bottom and top and lettered bottom to top on each side, see figure 5-3. Grid maps are read right and up; therefore, grid coordinates contain a number followed by a letter. At base option, a grided area overlay may be prepared for use with each grid map for pinpointing a more exact location within a particular grided square area. The overlay will be the same size as a grided area and contain smaller numbered grids. Figure 5-4 is an example of an enlarged grid overlay.

Using figure 5-3, we see that there is a white "X" inside a dark circle. The grid coordinates for this mark would be 11F (eleven foxtrot). For a more pinpoint location we could develop an overlay such as the one in figure 5-4 and have a coordinate of 11F13.

Normally, the base master plan (a layout of the entire base) is used for on-base grid maps with each grid area not exceeding 1,000 square feet and



1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

Figure 5-4. Grid map overlay.

marked for every location of any point within the map area. A 15-mile off-base map will be lined to indicate 1 mile square grid areas and marked for every location of any point within the map area.

Grid Map-Line Identification. Some of the maps you may use as grid maps may have all numbers and no letters on them. These maps are standard military maps based on the Universal Transverse Mercator Grid (UTM) such as shown in figure 5-5.

This type of map is also read right and up, the only difference being using a series of numbers and no letters. Overlays such as the sixteen-square one shown in figure 5-4 are NOT used on this type of map. For more pinpoint locations each square is divided into 100 smaller squares, as shown in figure 5-5. If the size of the map permits, the smaller squares may also be subdivided into 100 smaller squares. Normally, the subdivision lines are not shown on the map with only the larger squares being shown such as 7040. A 100-square overlay may be developed to save time in pinpointing locations.

Coordinates given for this type of map consist of 4, 6, or 8 digits. There must always be an even number of digits in the coordinates, or the location cannot be determined. NEVER take for granted a zero or any other number in a grid coordinate.

When reading the UTM type maps, you always read the vertical line, to the right, first and then the horizontal line, up, last. Separate the digits of the given coordinates into two equal groups and read right and up.

Let's go back to figure 5-5 for a couple of minutes. You'll notice an "X" in a circle just off-center on the map. Given the coordinates of 7040, you can find the "X" but it wouldn't be easy. Given the coordinates of 7644 narrows down the search area a great deal. To really pinpoint the center of our "X," we could give a coordinate of 765445; that puts us right on the money.

Grid Map-Radial Distance Identification. Many times, the location of a downed aerospace vehicle is not known, or the information received about its location is doubtful or incomplete. Air-search aerospace vehicles are often used to spot crashed aerospace vehicles or other incidents in such situations. If the spotting aerospace vehicle has located the downed aerospace vehicle, notification is made. The notification of the location is usually radioed back to surface radio receivers. The information will be transferred to plotting charts and grid maps, usually at Base Operations. From these charts and maps, the grid coordinates (line or block identification) are obtained and relayed to all concerned activities. An example of a pilot's message might be, "I'm approximately 10 miles from base, on heading (compass) 340°, and the downed aerospace vehicle is directly below me." This information is used to place a mark on your map. If the search aerospace vehicle is unable to give more-or-less exact location information and is within range of base radar, his location can be plotted on the radar screen. The radar plotting information is relayed to Base Operations and is handled in the same manner as the radio information. Once the location of the downed aerospace vehicle is marked on a map, map grid coordinates are then known and forwarded to activities such as the fire department, disaster control, and hospital.

Let's go back to figure 5-3 and see how this works. Notice at the top of the figure that there are three lines extended from the center of the map and numbered (from left to right) 340, 350, and 360. These are radial distance lines which were added to the map using a compass and straight edge. They indicate the compass headings from the center of the map and are normally entered in 10° graduations. On an operational map, the radial distance lines will show the full 360° of the compass in ten degree graduations; but for our purpose the three lines shown are all that are necessary.

The pilot has notified the control tower of the spotting 10 miles out on a heading of 340°. When this information is put on the map, the dark dot, we can then give grid coordinates of 5J or 5J7.

NOTE: You will note that the distance between grid lines on this map are not the one mile, as required, but are 2.5 miles. The 5, 10, and 15 mile circles were added to this map to give you an idea of what an off base map will look like. This map was used as an example only, as a true scale map showing 15 miles and having readable features would be much too large to include in this package.

Exercises (232):

Use figure 5-5 to complete exercises 1 through 4.

1. A/an _____ is located at grid coordinates 7856.

89

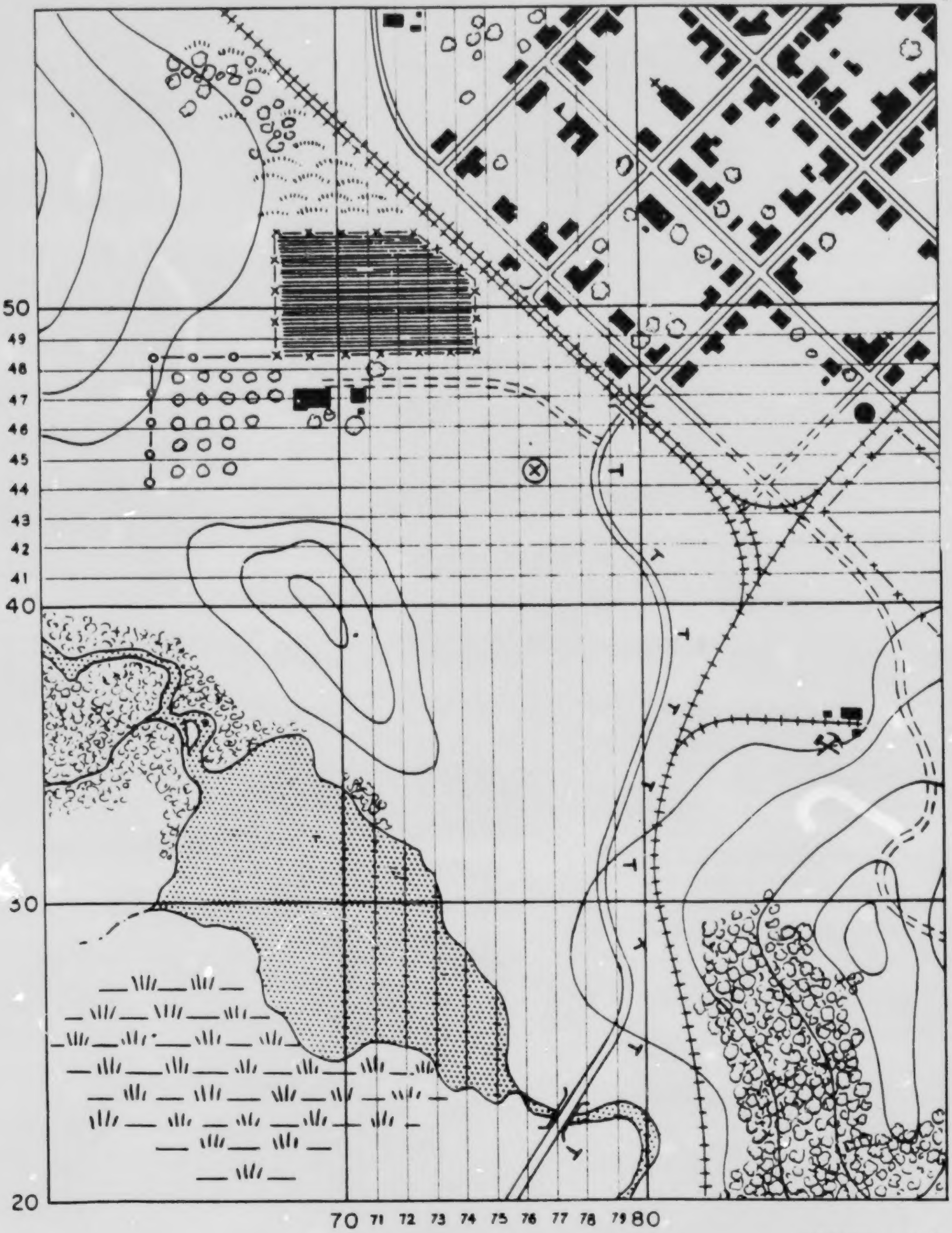

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Figure 5-5. Grid map-line identification.

99

2. A/an ____ is located at grid coordinates 6536.
3. A/an ____ goes under a/an ____ at grid coordinates 798468.
4. The symbol for a mine is located at grid coordinates ____.
5. Describe the land in square 8020.
6. Grid maps are read ____ and ____.
7. Each grid on an on-base grid map will not exceed ____ square feet.
8. Off-base grid maps cover a distance of ____ miles.
9. Compass heading lines used on a grid map are known as ____ ____ lines.

233. State what information must be on maps, charts, and status boards in the alarm center, and your primary duty in maintaining them.

As stated on the first part of this chapter, you will be required to read and maintain the various maps, charts, and status boards.

Maps. The maps required, by regulation, to be in the alarm center are: on- and off-base grid maps; installation layout map showing roads, terrain features, facilities, building numbers, fire hydrant locations, fire-alarm box numbers, crash fences, and other factors which might affect effective operations.

Explosives location map. An area map showing all explosives areas or locations with their applicable hazard symbols must be conspicuously displayed in the alarm center. A base plan must also be prepared to insure that the fire department is notified each time explosives movements occur.

Fire alarm location map. This map shows the location of all alarm transmitters, water-flow alarm, and emergency power sources supporting these systems.

Flight line ramp and airfield map. The aircraft parking positions and expected fuel flow (for large spills) are shown on this map.

Utility Charts. The following utility charts must be available in each central fire alarm center.

Water-distribution. Water-distribution system utility drawings showing pipe size, grid, numbered hydrants, and sectional valves are required. Also show all available water sources which could be used as emergency water supplies; such as wells, streams, swimming pools, etc.

Electricity, gas, and POL. Electricity, gas, and POL distribution drawings are provided showing the location of emergency shutoff valves in order to isolate particular base areas.

Status Boards. The status boards found in alarm centers will be determined by local or command directives. Some examples of the status boards you may encounter are: firefighting vehicle capability boards; street/hydrant/alarm status boards; and barrier status board.

Reading Charts/Boards. Each chart or map should have a legend, scale, or schedule section that gives specific details for that drawing. This information should never be removed or covered. Consult the legend to determine the type or size of valve, outlet, etc., you are checking on. If the status boards are not self explanatory, add similar blocks with directions for reading them.

Maintenance of Maps, Charts, and Status Boards. Your part in the maintenance of these items will be mostly to see to it that the information on them is kept current and that the item itself is legible and in good repair. To maintain the currency of the items will require telephone calls to the various sections. This is normally done before shift change each day so you can give the latest information to the on-coming shift. If you receive information at any other time, make the necessary entries or deletions and notify the fire chief at once.

At least once each year, check the items themselves to be sure they are the most current copies. This can normally be done by checking the update date on your copy with the master copy (usually kept at Civil Engineers).

Exercises (233):

1. How are explosives areas or locations shown on the explosives location map?
2. On what map are aircraft parking positions shown?
3. Where would you expect to find information about the location of emergency water supplies?
4. Where would you get specific information for a specific drawing?
5. Most of your maintenance of the maps, charts, and status boards will be to ____.

CHAPTER 6

Natural Cover and Miscellaneous Firefighting

MOST OF US think of our firefighting activities as either crash or structural. This may be because that is the way we think of our assigned vehicles. There are two other important areas that we must learn also. These are Natural Cover and Miscellaneous Firefighting.

The vehicles that we have on hand are the ones used in combating these types of fires. In most cases, the structural pumpers and/or water tankers are used before the crash trucks, but the crash trucks can be very effective on certain types of fires when used properly.

You receive a call at 0247 hours that some drunk has smashed his car into a tree and both are burning; what vehicle(s) would you send and how would you classify the fire? In most cases you would roll a pumper, rescue truck and tanker and classify the incident as miscellaneous (vehicle).

6-1. Natural Cover Firefighting

The average Air Force base is subject to fire emergencies involving structural, natural cover, and aircraft hazards. Some bases, however, have no flying activities. Thus, these base fire departments will not be involved with aircraft-fire emergencies. Some Air Force bases encompass large unimproved areas. On such installations, natural cover firefighting becomes of prime importance. On other installations, missiles and their related systems, fuels, and oxidizers are the fire department's major concern. It can be seen then, that all three of the phases of fire protection are of equal importance to fire protection personnel, even though the importance of the different phases varies from base to base. In this chapter, the subject of providing fire protection for natural cover and miscellaneous fire hazards will be covered.

As a qualified fire protection specialist, you must have a good working knowledge of natural cover firefighting. You must understand the hazards created by natural cover fires and the procedures to be taken to minimize their spread, reduce their destruction, and prevent their occurrence. Every senior member of an Air Force fire protection organization can be placed in the position where such knowledge will mean the difference between life and death, or between saving and losing valuable property. This is the subject of our discussion. Let us begin by discussing the general nature of natural cover fires.

234. State the cause and effects of natural cover fires, and name the various types of fires and their parts.

Natural Cover Fires. Natural cover fires involve grass, weeds, grain, brush, forests, or any other plant life. Forest fires are no doubt the most acute of all natural cover fires from the standpoint of a national fire problem. Forest fires involve more than the immediate monetary loss; this is insignificant compared with the effect on the future water supply and timber supply and with the loss of hunting, fishing, and recreational facilities, to say nothing of the loss of life which may occur. A single forest fire in Minnesota is known to have taken 559 lives, a fact that emphasizes the importance of organized fire safety before such catastrophes occur.

Forest fires are also of great concern to fire protection personnel in that such fires frequently involve farms, villages, and towns. For this reason, fire protection organizations are called upon to handle both structural and natural cover fires. During recent years, the Nation has become increasingly conscious of the importance of the prevention and control of fires in camps and buildings, for these fires may propagate forest fires.

The great majority of natural cover fires are caused by man as the result of his carelessness. The natural elements, such as lightning, the sun, and the wind, are responsible for the insignificant remainder. Careless hunters; campers; fishermen; and frequently, local residents account for more fires than any other causes. Other causes of forest fires include locomotives, burning of rubbish, lumber operations, and arson. The most effective means of combating these fires should be initiated before the fire actually occurs—through the medium of law enforcement, restrictions, education, and the complete elimination of hazards in critical areas.

Prompt discovery of natural cover fires is essential in achieving quick control and limiting damage. In areas where efficient detection, control, and extinguishment organizations are present, fires rarely get out of control and damage is kept to a minimum. These methods of detection include ground and air patrols and forest observation towers.

An adequate system of trails and roads, properly distributed, built, and maintained through the area, is of utmost importance in making the fire area reasonably accessible to firefighting forces and their equipment. Roads of proper width are also invaluable as firebreaks that prevent the spread of fire beyond a limited area. In many instances, it is deemed necessary to clear strips for permanent firebreaks.

Aircraft of various types are now being successfully used to transport men and supplies to the scene of forest fires—especially such areas as may be devoid of trails and roads. Parachute-jumping firefighters started extensive training before World War II, and they have expanded and improved their effectiveness consistently during each succeeding year. In the years following the war, considerable experimentation and test flying using helicopters has been performed successfully by the Air Force. For forest-fire extinguishment by aircraft, the "water-bomb" and other airborne devices are now being used with great effectiveness.

Training and organization are essential to suppress forest fires successfully. Under extensive emergency conditions, it is frequently necessary to use all able-bodied personnel within an area. At such times, it is of utmost importance to have well-trained men available to organize and supervise the untrained force. The complete and extensive training of fireguards and lookout men is paramount.

The equipment used must be adequate and suited to the immediate environment. This implies, for example, that large vehicles will not be used where roads are narrow and where there are small bridges with a limited capacity. Areas where the water supply from ponds, lakes, and small streams is plentiful might advantageously use several portable pumping units, but these units would be useless where water is scarce. In some areas, water cans equipped with a hand pump are carried on the backs of personnel. For fires in logging woods, water tanks mounted on pump-equipped trucks are sometimes used, as are railroad tank cars filled with water.

Where an airbase is involved or where a target or bombing range presents a natural cover fire hazard, the use of incendiary bombs, flares, tracer bullets, high explosives, and other ammunition requires fire protection crews to be exceptionally alert, as many of these missiles are capable of igniting combustible materials upon contact. This danger is particularly acute in dry climates and during dry seasons. The potential damage of this type of fire is much greater than that from fires in unadjoining buildings, because natural cover fuel is plentiful and uncontrolled fires may cover hundreds of square miles. Obviously, quick control of natural cover fires is important because of the damage they cause: waste of raw materials, ruined military equipment, the destruction to installations, the loss of lives, and the waste of the large amount of manpower needed to check a large fire.

Natural cover fires are capable of moving very rapidly, especially when the wind velocity is high. The perimeter, or fireline, is the hottest part of the fire. The interior of the fire is a smoldering mass, with comparatively few flames and with many glowing embers or sparks. Natural cover fires are best controlled along the fireline.

Types of Natural Cover Fires. Natural cover fires are divided into four distinct types—ground fires, surface fires, crown fires, and spot fires. Each of these types of fires is subject to variation in speed of fire propagation; size, type, and quantity of fuel involved; and the procedures required for extinguishment.

Ground fires. Ground fires travel at ground level or below the surface. Dry leaves, humus, peat, and other organic materials that have become part of the soil are the fuels. These type of fires are also known as undergrowth or duff fires.

Surface fires. Surface fires burn over grass, weeds, grain, brush, and shrubs. This type of fire travels rapidly if the wind is high and when the fuel is dry and abundant. The heat is intense but short-lived because of the quick-burning characteristics of the fuels.

Crown fires. Crown fires are in the tops of trees and in high brush. When the heat generated by flash fuels at the surface is intense, the fire advances upward on the dried lower limbs of trees and continues to burn in the treetops. This condition occurs mostly in dense forests and then only on steep slopes, in draws and canyons, or during high winds. A crown fire is the most feared of all natural cover fires. The enormous flame area draws the air for hundreds of yards from the fireline; this, in turn, generates such heat that direct control is almost impossible. Indirect methods, such as firebreaks (either natural or manmade) and backfiring, are the best means of controlling large crown fires.

Spot fires. Spot fires are started in advance of the heads by windblown sparks or bits of burning material, as shown in figure 6-1. They are capable of creating a very dangerous situation. A number of spot fires may merge and create a new head in advance of the main fire. Men and equipment may be trapped between these fires, and large losses may result. A well-organized patrol must be constantly on the alert to locate spot fires and get them under control before extensive damage results.

Parts of a Natural Cover Fire. The point where the fireline is progressing fastest is called the *head*, as shown in figure 6-1. A natural cover fire may have any number of heads, depending on the type, abundance, and location of the fuel. Fire heads generally travel with the wind; the stronger the wind, the greater the speed of the fire. Because of frequent directional changes of the wind, varying types and quantities of fuel, and topographic conditions, natural cover fires have irregular perimeters, making control difficult and often dangerous.

The upwind, or windward, portion of the fire is called the *tail*. Usually the tail is in or near the general vicinity of the origin of the fire. All portions of the fireline between the tail and the various heads and those slower burning areas between the heads are called *blanks*.

The rate of burning of natural cover fires depends primarily upon the velocity of the wind, type and abundance of fuel, and general topographic conditions. The head of the fire travels at a rate proportional to the wind velocity. Wind carries additional oxygen to the fire and increases the rate of burning. The hot air rising from the fire causes a partial vacuum. Cold air, with a fresh supply of oxygen, rushes in at the base. The larger and hotter the fire, the stronger is this draft created by the fire.

Fire heads move faster uphill and through draws or canyons than on level ground or downhill, other conditions remaining equal. Heads burning uphill dry out and vaporize fuel faster than those burning on level ground or downhill. The upward rush of cold air acts like the draft in a chimney and speeds burning accordingly. Heads running up draws, valleys, or canyons cause the inrush of cold air with a new oxygen supply to be concentrated in a small area and, as a result, the fire propagation rate is greatly increased. This condition is similar to a forced draft in a

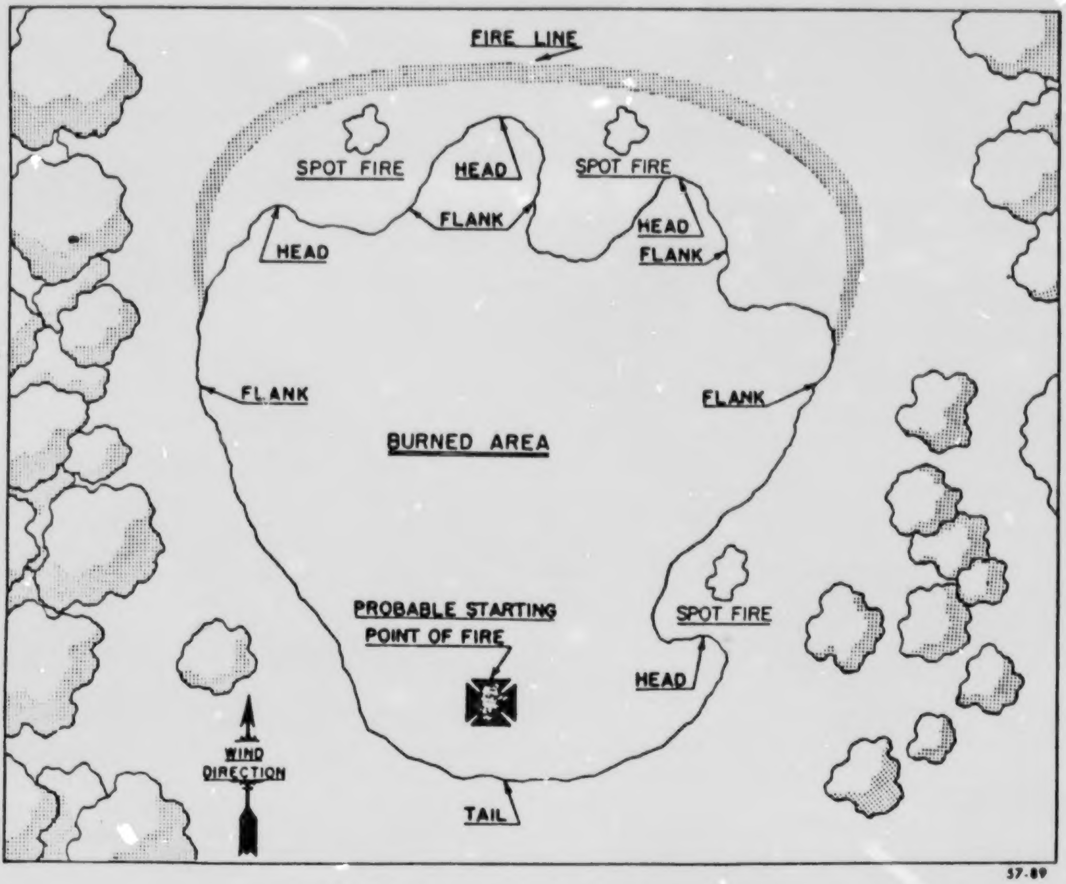

Figure 6-1. Natural cover fire spread and parts.

blacksmith's forge, fanning the fire to a greater speed and intensity. Men or equipment should never approach the head of a fire from downwind when the approach necessitates travel in a draw, valley, or canyon.

Never attempt to control a running fire from the uphill direction. This entails a high risk to men and equipment. The correct point to begin control is at the *tail* on the *upwind side* to the fireline or at the head of the fire when it tops a crest and starts its slower, downhill burning. The natural draft is counter to the direction of run, making it possible to control the fire before the head gains new momentum.

Exercises (234):

1. From the standpoint of a national fire problem, what type of natural cover fire is the most acute?
2. The immediate monetary loss from forest fires is insignifiant when compared with what long term effects?
3. The majority of all natural cover fires are caused by _______ as a result of ___ _______.
4. What is essential in achieving quick control and limiting damage from natural cover fires?
5. What two requirements are essential to supress forest fires successfully?
6. What is the hottest part of a natural cover fire?
7. Natural cover fires are best controlled where?
8. What are the four distinct types of natural cover fires?
9. Fires in humus, peat, and other organic materials that have become part of the soil are known as _______ fires.
10. A _______ fire burns with intense heat but is short-lived because of the quick-burning characteristics of the fuels.
11. What type of fire burns through the tops of trees and high brush?
12. When a fire is started in advance of the heads by windblown sparks it is called a _______ _______.
13. The point where the fireline is progressing the fastest is called the _______.
14. The windward portion of a natural cover fire is called the _______.
15. What are the "flanks" in a natural cover fire?
16. Where is the fireline located in relation to the tail of a fire?

235. Tell how specified tools and equipment are used in natrual cover firefighting, and make recommendations for their application in a hypothetical firefighting program.

The tools and equipment available for your use in combating natural cover fires will vary with the location of your base, the physical properties of the installation, and the civilian fire protection organizations in the surrounding area. If your base is located in an area where the possibility of large or frequent natural cover fires is great, mechanized natural cover firefighting equipment such as tractors, bulldozers, graders, and assorted trucks would probably be available from the Air Force as well as from civilian firefighting organizations in the area. If, on the other hand, your installation is located where natural cover conflagrations are uncommon, your firefighting tools and equipment would probably be limited to common firefighting handtools; gardening tools; backpack water tanks; and other local, makeshift firefighting equipment. This section discusses the more common types of equipment, both mechanized heavy equipment and handtools, used by Air Force fire protection organizations to combat natural cover fires on their installations or to help local civilian firefighting crews.

Powered Equipment. Power-driven equipment is available for natural cover firefighting in a wide variety of designs and sizes. Powered equipment ranges from 1-horsepower, 20-pound chain saws through 600-horsepower, 20-ton bulldozers. Such powered equipment is used primarily to construct the firebreaks and barriers. Powered handtools can be used to fell trees, clear brush, and eliminate heavy brush growth in an effort to confine fire spread. Heavy equipment, such as plows, drags, graders, bulldozers, and trenchers, is used primarily to clear wide strips of bare soil in the path of an oncoming fire. Use of these large mechanized pieces of equipment surpasses all other methods of fireline and firebreak construction through heavy forest fuels. However, it requires costly equipment to move them to a desired location; and in many cases, unless improved roads are available, they cannot be brought into use at all.

Many types of fire extinguishing equipment, ranging from hand-carried portable pumps through self-contained mobile firefighting vehicles with water capacities upward of 2000 gallons, are available for combating natural cover fires. In many instances, standard structural pumpers can be used for delivering large volumes of water over long distances through a series of relays. Collapsible canvas tanks (see fig. 6-2) are very useful for storing water in fighting natural cover fires. A pumper can be used to keep such a tank full, the water to be used as needed. For use around Air Force bases, a very effective self-contained firefighting vehicle can be made out of a converted decontamination truck equipped with an independent pump and six-wheel drive.

A very useful piece of equipment used in natural cover firefighting is the gasoline-driven portable pump, as shown in figure 6-3. The most common portable pump weighs approximately 75 pounds and can deliver 60 gallons of water per minute through a 1 ½-inch hose at a pressure of 100 pounds per square inch. The hoses normally used with this pump for natural cover firefighting are of two types: (1) rubberlined canvas-covered hose for durability and (2) unlined linen hose for lightness. Frequently, these portable pumps are hooked up in series to allow the movement of water over long distances or up mountainsides.

Handtools. Other than powered equipment, the equipment and tools used to combat natural cover fires are referred to as handtools. These handtools fall into two general groups: (1) those designed explicitly for the job of combating fires and (2) those known as *field expedients*.

A field expedient handtool is any item that can be used to combat a natural cover fire. Some of the more common tools used are axes, garden rakes and hoes, grass whips and scythes, shovels, mowers, grass combs, and large pieces of canvas and burlap. There is no limit to the number or diversity of items that can be classed as field expedients when it comes to natural cover firefighting handtools. In one northern state several years ago, a severe brush and grass fire was successfully controlled and extinguished almost entirely by the use of snow shovels! The snow shovels were used to beat out the fire, knock down fuel, and make a firebreak. Anything that can help you control or extinguish a natural cover fire should be pressed into service as a field expedient handtool.

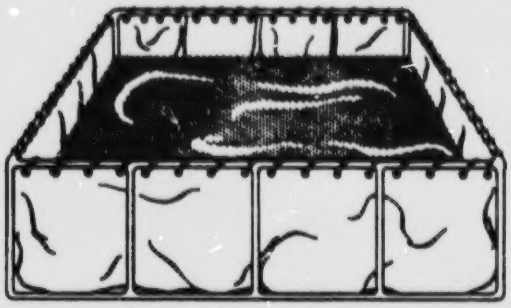

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Figure 6-2. Collapsible canvas water storage tank.

All common lightweight firefighting handtools can be of value to you in your efforts to control and extinguish a natural cover fire. Pikepoles can be used to push, pull, and move brush and other fuels. The firemen's axe and the undercutter (A and C in fig. 6-4) can be used to cut and clear fuels to form barriers and firebreaks at the fireline. In addition to handtools used in other types of firefighting, there are some handtools and other types of equipment designed especially for use on natural cover fires.

A fire broom, with replaceable metal fillers (see E of fig. 6-4) is very effective in knocking down grass and weed fuels to retard the spread of fire and to beat out fires. The brush hook (B in fig. 6-4) is indispensable in combating a fire involving heavy brush, bush, or thick grass. One swipe with this tool will cut down a small tree or the thickest brush, and large areas of thick vegetation can be quickly cleared with this tool. One of the best all-around natural cover firefighting handtools is the mattock (D of fig. 6-4). This tool can be used to chop, cut, clear, and dig. The mattock, because of its versatility, is one of the best handtools available to the firefighter in constructing firebreaks and forming a fireline.

Extinguishers. There are several types of portable fire extinguishers designed for use in combating natural cover fires. Figure 6-5 shows two of the most common extinguishers, both of which are carried on the back and have a water capacity of 5 gallons. The major difference between these two backpacks is in the operation of the discharge pump. The extinguisher shown at the bottom of figure 6-5 has a lever on the left side which operates the pump inside the extinguisher. The left hand is used to operate the pump and the nozzle is held in the right hand. On the backpack

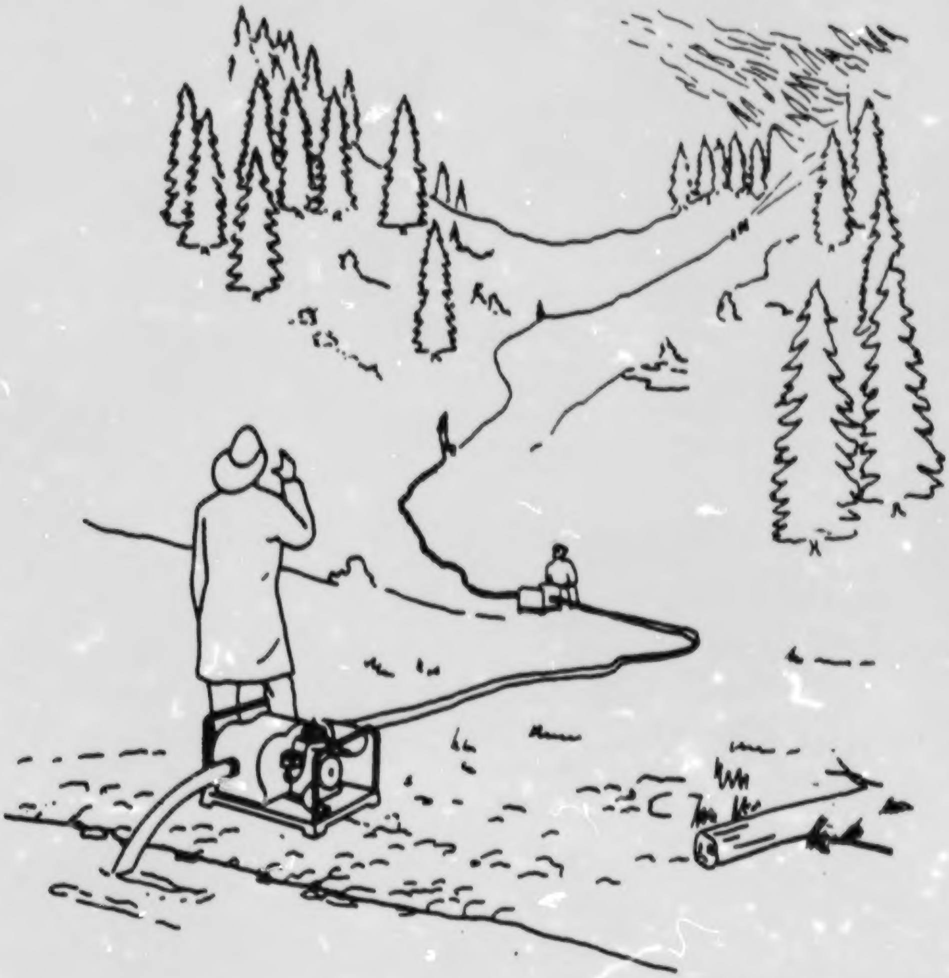

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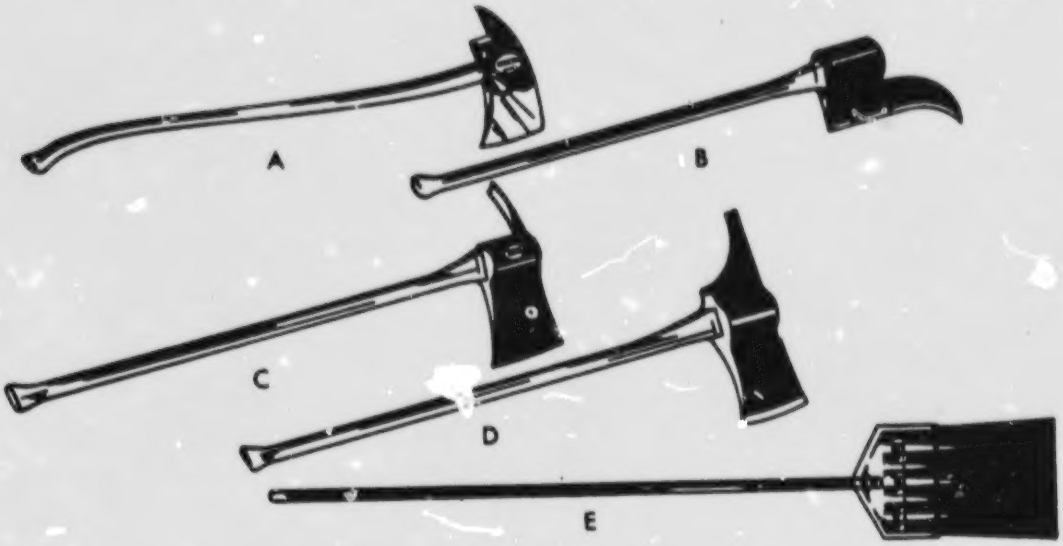
Figure 6-3. Portable pump units in use.

at the top of fig. 6-5, the discharge pump is in the handle of the nozzle. You operate it by sliding the handle back and forth with one hand while holding and aiming the front part of the nozzle with the other hand. These backpack extinguishers are very effective against slow-moving grass fires and for combating small spot fires. The limited capacity of these extinguishers causes them to be of less value when larger or fast moving fires are encountered.

Exercises (235):

1. How are powered handtools used in natural cover firefighting?
2. How are collapsible canvas tanks used?
3. The most common portable pump used in natural cover firefighting has a rated output of ____.
4. What type of 1 ½-inch hose is used in natural cover firefighting?
5. Which tool is used for knocking down grass and weed fuels to retard the spread of fire?
6. One of the best all-around natural cover firefighting tools is the ____.



A. Fire axe
B. Brush hook
C. Undercutter
D. Mattock
E. Fire broom

Figure 6-4. Firefighting handtools.

7. What is the capacity of the backpack extinguisher used in natural cover firefighting?

8. As a fire protection specialist, you are called upon to help a nearby civilian community evaluate its natural cover firefighting requirements. Your investigation reveals that the majority of the terrain consists of moderately heavy woodlands, with numerous large streams and quaint little covered wooden bridges.

   a. What factors influenced your decision?

   b. What fire protection recommendations should you give the community?

236. Determine methods for controlling and extinguishing various types of natural cover fires.

There are two general methods of organization for combating a natural cover fire—the sectional method and the "one-lick" method.

Sectional Method. The sectional method consists of placing a unit on a specific section of the fireline. Its mission is to stop the progress of the fire, extinguish it at the fireline, and execute mop-up patrol work. The unit has the full responsibility for that section of the fireline. This method is best used against a slow-moving fire.

One-Lick Method. The one-lick method is the fastest and easiest method to use on a running fire. A firefighting team is placed at the location designated as the fireline and ordered to work in a specific direction. From one to several individuals of a team knock down the hottest portions of the fire with backpack pumps, when water is available, and proceed along on the flank. Behind the initial unit, individuals pass through with axes and mattocks, each person taking one lick with his specific tool at the obstacle that most impedes the progress of the group in constructing a firebreak. For example, the individuals with axes, who are grouped together, may encounter a small tree directly in the path. The first person will swing once at the base of the tree and move onward. If the first person fails to sever the tree from its base, the second individual will swing his axe to strike the tree in the same spot. After severing the tree, the second person moves onward. If it is unnecessary for the third person to make a stroke or "lick" at that particular point, he will throw the tree from the break so that it will not become involved in fire. Behind the axes are several individuals who tear up the ground with mattocks, tools that may be used either as axes or as heavy hoes.

By this "leapfrogging," a continuous line of disturbed earth is created. Individuals with shovels then dig out all surface vegetation. They throw combustible material away from the fireline and spread whatever soil is picked up with the flinging motion on the burning portion of the fireline. The soil knocks down and extinguishes the fire. Earth must be shoveled with force to spread it as far as possible. A large shoveful of earth is required on a hot spot. Burning bits of humus, leaves, or rotten wood are thrown into the fire area. In this manner, a clear trench down to bare soil is extended along the fireline. The width of a trench is variable with the intensity of the fire and with the type, height, and denseness of the natural cover. Behind the people using shovels are one or two using axes to sever any trees, roots, or buried or rotten logs extending across the break. All material that will carry fire over the trench is eliminated. One person is left to patrol a specific section of controlled line. He may use a backpump and a shovel or other equipment to prevent any flareup from jumping the line and starting new fires.

There are many variations of attack organization, depending upon the type of fire encountered. In timberland, crews with saws and axes may be the first in line. Other axe and saw crews may have to cut paths or lines through windfalls or down timber. In heavy brush, it may be necessary to cut lines along the flank of the fire with brush hooks or axes before control is possible.

Grass fires in fields and prairies require a different organization of personnel, tools, and equipment. Here, backpumps, wet burlap, or strips of canvas or shirts are used to beat out the fire. In the one-lick method, each person performs a specific operation at intervals along the line and keeps moving from the tail along the flanks toward the head of the fire. When the last individual of the unit passes any point, the fire must be in complete control behind them. In areas where the rainfall is scarce and the sandy soil lies loosely on the surface, the soil is frequently the only plentiful extinguishing agent available.

Direct Method of Control. The direct method of control is very effective against natural cover fires but can be used only on moderately hot fires. Either the sectional or the one-lick attack may then be used. The firefighters are able to approach closely and clear a line through brush and woods and dig a trench or firebreak perhaps as near as 2 feet from the fireline, about 2 feet wide, and sufficiently deep to reach mineral soil. Mineral soil is spread on the fire, and organic soil which may be burning is thrown inside the fireline.

Grass and grain fires are often controlled by plowing furrows or by making firebreaks along the firelines with bulldozers or graders. Lines are patrolled by individuals beating out the fire with shovels, burlap sacks, or tree branches. Drags are sometimes pulled behind tractors or other vehicles. Plows and drags also can be used in brushlands when the brush is small enough to permit maneuvering heavy equipment.

Fires in flooded meadows and marshlands may be checked quickly by marching a team of firefighters along the outside of the fireline. The grass and rushes are trampled into the water or muddy ground to prevent ignition.

Structural firefighting organizations may use their vehicles effectively on the one-lick method in spite of the fact that they can supply a steady stream of water for only a few minutes. Backup lines should be laid from the pumpers or trailers if a water source is available. Fog is recommended for natural cover fires except where the burning is deep-seated in large pieces of fuel.

Indirect Method of Control. The indirect method of natural cover fire control entails the use of firebreaks or barriers. Natural fire barriers consist of lakes, rivers, creeks, deserts, or bare rock formation. These barriers will halt a natural cover fire if they are wide enough to prevent spread of spot fires. Natural barriers may be augmented by artificial firebreaks.

Firebreaks. Artificial firebreaks consist of roads, highways, survey lines, transmission lines, or cleared areas. Specific lines may be cut to prevent the progress of fires that may break out in the future. Firebreaks must be at least twice as wide as the height of the surrounding natural cover types. These breaks should be cleared to conform as nearly as possible with the ridge lines and to connect natural barriers. Firebreaks must be cleared of brush and grass to keep fire from traveling through these flash fuels. Most permanent firebreaks include small trails built in conjunction with the breaks.

Backfires. Backfires are employed to burn back toward the advancing head, thus creating a fast firebreak and stopping the fire because of a lack of fuel. Backfires are normally used where a suitable network of firebreaks already exists. Backfiring should not be attempted except on the orders of an officer who is fully aware of existent conditions. Improper backfiring causes loss of control of the fire and may trap personnel working on the line. Great damage and loss of life and equipment may result when backfires are improperly executed. The *whereabouts of all personnel and equipment* must be known before any backfiring is started. Before a backfire is lighted, sufficient personnel and equipment must be on the job to control the resultant fire. Wind directions and velocity must be considered in conjunction with either natural and/or artificial

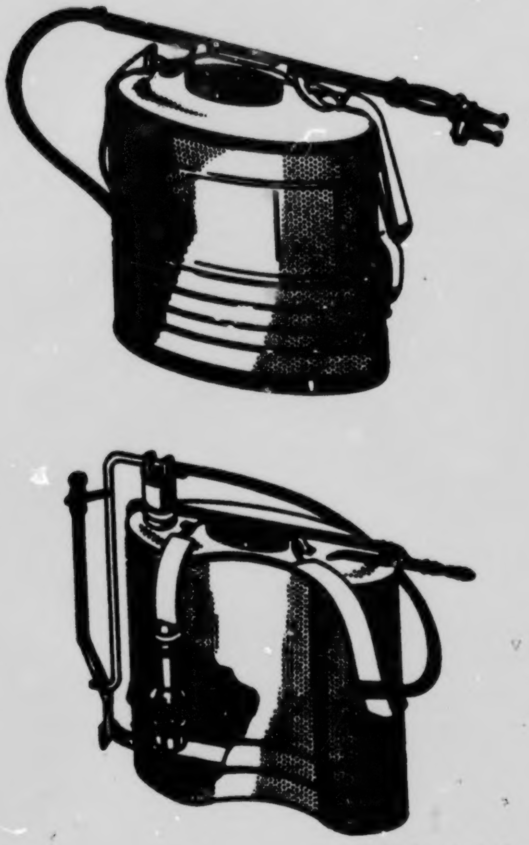


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Figure 6-5. Backpack water fire extinguishers.

firebreaks. Whenever possible, the backfire should move uphill and reach the ridge almost simultaneously with the head of the original fire. At this point, the main fire may be halted. Backfires may be started with matches by using oil-soaked torches, or by flame-producing devices, if available.

Self-Protection. When you are fighting natural cover fires, you must be constantly aware of the dangers to you and your fellow firefighters. All unessential personnel in the fire area should be warned of the danger and evacuated. Buildings endangered by the fire should be searched for occupants that need to be evacuated. This will reduce the life hazard for the occupants and for you as well, since you will not then be forced to return later in an attempt to rescue such persons. Always be on the alert to keep yourself and your personnel from becoming trapped by the fire. As you know, natural cover fires can move at extremely fast speeds. If it appears that you might become trapped by a fire or if you find yourself surrounded by a number of spot fires that are closing in, try at once to find some sort of refuge. Rivers, streams, lakes, firebreaks, and gulleys offer relatively safe places of refuge from the heat of an approaching fire.

If you are trapped by a fire or if you find yourself ahead of a fast-moving fire and no refuge can be found, there is one "last chance" action that you can take. By lying face down on the ground and covering your head with your coat or shirt (wetted if possible), you can escape most of the fire's heat. Then, when the head of the fire approaches and the heat becomes too intense, you can try running through the head of the fire to the burned-out area behind it. If the vegetation is not too thick or the head of the fire too wide, you stand a rather good chance of escaping this way. Remember, though, this is a "*last chance*" action. Always make every effort possible to avoid a situation that would make such an action necessary.

One of your most important self-protective thoughts in fighting a natural cover fire is your *location* in relation to the fire, the wind direction, and logical fire travel. As an example, never attack a natural cover fire when approach necessitates travel in a draw, valley, or canyon. If the fire could not be stopped or if the wind direction and speed were to change, you and your people could very quickly find yourselves facing an approaching fire head with no place to go.

Another example of a dangerous situation that inattentiveness to probable fire travel can create is found in trying to attack a fire from an uphill direction. As you know, a fire travels faster and burns much hotter moving up the side of a hill. Positioning yourself uphill of an advancing fire is like placing yourself in front of a blast furnace that is being wheeled forward.

No one can sit down and tell you how to avoid *all* hazardous conditions you and your personnel could meet in combating a natural cover fire. Only your intelligence, knowledge of existing conditions, and awareness of the fire situation as it exists in your location can be of value in making the right decision that will insure self-protection.

Patrol and Mop-Up. Once the fire in one sector is under control, make provisions to prevent the fire from jumping the fireline or reigniting. Placing individuals on patrol at intervals along the fireline and equipping them with shovels, backpack pumps, and other available equipment is the best way to assure that the fire will remain under control. Such a group of firefighters on patrol can cover an area for several hundred yards outside the fireline, searching for spot fires and extinguishing them promptly upon detection. If the spot fire is large or cannot be controlled, help should be summoned before a conflagration evolves.

When the entire fireline is under control and all progress of fire heads is stopped, mopping-up procedures should be started. These include extinguishing every spark or ember in the fire area, because inside the fireline, a mass of burning embers, a smoking stump or log, or burned foliage may flare up with the first gust of wind. Mop-up is best accomplished by working one strip or band, of the area at a time. A band extending a certain distance inside the fireline is mopped up first. Then, other bands of specified widths are covered successively until the entire burned area has been covered and the last spark put out.

Because of the irregularities of the fireline, many small patches of unburned fuel may remain inside the fire area. If there is any danger of a flareup after the main control unit has passed, the area should be burned over, much in the same manner as in a backfire. Single stumps and logs should be carried a safe distance inside the fire area, torn apart, and covered with water or soil. When stumps and logs cannot be moved, a trench should be dug around them to the depth of mineral soil and the hazard covered with dirt. Concentrations of logs, stumps, and similar fuels should be separated and treated as single hazards.

Stump craters are holes in the ground where large stumps have been burned out. The holes left by the burned roots are normally full of burning embers. These holes should be filled and packed with soil to smother the fire and prevent outbursts of flame. Burning snags and trees standing near the fireline should be cut down and treated by trenching and covering with soil. Burning snags well within the fireline are treated in the same manner, since sparks from these snags can be carried a great distance by the wind and are frequently capable of starting new fires.

All dry sod, strawstacks, and similar materials should be checked and soaked thoroughly with water and treated by the trenching and covering methods. All burning objects on hillsides should be trenched deeply enough to catch any burning embers that might roll downhill and across the fireline. Large logs should be moved so that they cannot roll downhill. After all evidence of smoke, flame, and sparks has disappeared, a small patrol should be kept on duty in the area of the fire to quell quickly any further outbreaks of fires.

Since your actions in final control and mop-up operations cannot be predetermined, your best course of action is to grasp the basic factors presented here, then apply these factors as needed. As your degree of experience in natural cover as well as other types of firefighting increases, your ability to apply the general knowledge you have gained from this course will also increase.

Exercises (236):

1. A slow-moving fire is best combated by using the ______ method.
2. The fastest and easiest method of combating a running fire is the ______ method.
3. You are in charge of a crew on the fireline of a natural cover fires and have directed your crew to use the one-lick method to form a trench to control the fire. What factors will affect the width of the trench your crew is to construct?
4. In directing a firefighting crew combating a natural cover fire in a large grass field, using the one-lick method, you should have your men moving along the ______ , from the ______ toward the ______ of the fire.
5. Which method of control can only be used against moderately hot fires?
6. In using a P-8 pumper on a fire in a wheat field, what type of stream would be most effective?
7. Natural barriers are used in the ______ method of controlling natural cover fires.
8. To construct a firebreak in an area where there are trees 22 feet tall, you should make the firebreak at least how many feet wide?
9. To create a fast firebreak and stop a fire due to lack of fuel you should use a ______ .
10. You have been directed to set a backfire to stop a large running fire. What factors must you consider before starting the backfire?
11. You have been fighting a fast-moving fire and discover that several spot fires have sprung up in back of you. A quick look around tells you that there is no way out and no refuge to be found. What should you do?
12. You are in charge of a crew assigned to fight a natural cover fire. Arriving at the scene of

the fire, you quickly evaluate the situation. Your evaluation reveals that you and your crew must travel through a large canyon to reach the fire. Before making an approach, what factors must you consider? How do you advise your crew?

13. When should mopping-up procedures be started in natural cover firefighting?

14. When you are mopping-up on a steep hillside, what should you do to prevent burning embers from crossing the fireline downhill?

6-2. Miscellaneous Firefighting

When a building goes up in flames, it is easy to classify that fire as a structural fire. An aircraft crash or brush fire is equally easy to classify. How would you classify a fire in a coal pile, dump, ground power generator, or dumpster?

Normally, miscellaneous fires are very hard to cover in a prefire plan. In the case of the coal pile or dump, you could make a prefire plan because these things don't move very often. The generator and dumpster pose an additional problem to firefighters—they are mobile. Can't you just see yourself trying to make a preplan for a dumpster that is on the back of a truck heading for a dump?

237. Identify facts about miscellaneous firefighting.

A miscellaneous fire is one that does not readily fall under the category of aircraft, structural, missile, weapon, or natural cover fire. This leaves us with a bunch of fires that occur all too often. These types of fires are very hard to train for and can present us with many problems. Let's take a look at some of these fires and discuss them.

Automobiles. Normally, car fires occur in the electrical or fuel systems and, to a lesser degree, the interior. There is always a shock hazard until the battery is disconnected and/or removed. There is little chance of explosion as long as a fuel fire is confined to the engine but this chance becomes greater as the fire spreads toward the fuel tank. The location of the fire and the type or material burning would dictate the agent to be used and its application. You wouldn't know how to fight the fire until you saw it.

Trucks. Trucks present the same basic problems as cars with a couple of extra thrown in for good measure. In most cases, you won't know what the truck is hauling, if anything, until you get to it. A big problem with the larger trucks is the wheels. Should there be an overheated brake or such, the rim may explode with destructive force.

Rail Stock. In most cases, you won't know what or how much material is involved in a train fire even after you get to it. Boxcars often have mixed loads in them, which compounds your problems. You must make every effort to determine the contents of a railcar before combating a fire in or on one. Another big part of the problem will be just getting to the fire itself. Railroad tracks aren't layed in the most convenient locations, and if you have to follow the tracks you're in for a rough ride.

Aerospace Ground Equipment (AGE). AGE equipment is varied in its size and function. It goes from small heaters with only a few gallons of fuel to large power units with many gallons of fuel. There may also be an electrical hazard with some of this equipment. You should become familiar with each type of AGE equipment used at your base to determine the most effective manner of combating fires in these units.

Dumpsters. Normally, you can get some idea of what is in a dumpster from where it is located, but then again you never know for sure. A lot of people like to "unload" into a dumpster away from their shop or home just so investigators won't be able to find them. At one time or another, just about anything you can think of has gone into a dumpster. For this reason you should use extreme caution when you fight fires in dumpsters. Never poke your head into a dumpster until it has been well ventilated. Not only do they stink but there may be harmful vapors inside.

Dumps/Landfills. Treat these areas the same as dumpsters. Normally your firefighting efforts will be limited to applying large amounts of water to extinguish the fire. Should it become necessary to walk over a dump or landfill area in fighting a fire, be sure you use a lifeline. There may be places that look like they will support your weight but won't. In most cases the area on fire should be covered with earth to control the fire.

Agricultural. Most of the fires you may encounter in agricultural products will be on mutual aid runs. The biggest problems come in storage of these products. Grain elevators have been known to explode, with little or no warning. This is due to excessive dust accumulation during filling. The fires in these elevators will usually require large amounts of water to extinguish the anticipated deep seated fire in the grain. Loose hay stacks and/or hay bails will also require large amounts of water. These fires are somewhat easier to combat in that the material can be scattered with a pike pole without too much trouble.

As you can tell from the few examples given, miscellaneous fires are widely varied. In fighting any miscellaneous fire, common sense and knowledge of basic firefighting principles will be your keys to success. You will have to know what is involved to determine the proper agent to use and how to use it. Always keep in mind the safety of your crew and yourself, and act accordingly. Dead heroes aren't much help to anyone.

Exercises (237):

1. What are miscellaneous fires?

2. Besides the hazards related to the fuel, what hazard do automobile fires always present?

3. What special hazard do large trucks present?

4. The agent to be used on a miscellaneous fire will be determined by ______________ .

5. How should you prepare yourself to combat a fire in aerospace ground equipment?

6. When should you use a lifeline in combating a dump or landfill fire?

7. Fires involving agricultural products will present you the biggest problem in their ______ .

CHAPTER 7

Missile Fire Protection

MISSILE PROPELLANTS are grouped into two main classes, solid and liquid, and are further divided into monopropellants and bipropellants. The *Interstate Commerce Commission* classified these materials according to their most prominent characteristics, ranging in hazard from nonflammable through flammable, poisonous, corrosive, and explosive. In general, missile propellant fuels and oxidizers are highly reactive chemicals. Many possess extremely hazardous properties. We must consider these hazardous properties and take adequate precautions during all storage, handling and fire control operations to prevent serious personnel injuries and/or accidental fires. Should an accident occur, prompt action is imperative. Decontaminate personnel and give first aid immediately. We must use only extinguishing agents that we know are compatible and effective. Many standard extinguishing agents produce undesirable reactions (such as explosions) when they contact missile propellant fuels and oxidizers. Careful consideration must be given to the selection of storage sites, construction material, disposal sites, and safety features.

7-1. Liquid Propellants

The ultimate in missile fuels and oxidizers has not been achieved. Scientists are continually trying to develop a fuel with more power so that man can travel farther into space. We do not expect you to become scientists, or even qualified fuel handlers, but it is possible that you will be called upon to combat and control a fire involving fuels or oxidizers. The fuels and oxidizers covered in this section are the more common ones. You must understand their characteristics to perform your duties in the field of missile fire protection. Missile propellants and oxidizers are, in general, highly reactive chemicals. Many of them are hazardous to the firefighter because of their toxic and explosive potentials. Others are extremely cold or highly corrosive. Some may have all of these characteristics, any one of which will complicate your operation.

238. State dangers in dealing with liquid propellants, and give some of the major precautions.

Liquid propellants, normally comprised of a fuel and an oxidizer, are maintained as separate units until they mix in the combustion chamber at the instant of firing. This type propellant is a bi-propellant. Some liquid propellants have fuel and oxidizer pre-mixed and are in a single independent unit. Like solid propellants, these are called monopropellants.

Because liquid propellant fuels and oxidizers are usually such, highly reactive chemicals, the greatest hazards they present are toxicity, fire, and explosion. Anyone who comes into contact with these products must constantly guard against these hazards. (The primary hazard of any missile, of course, is the warhead.)

A guide is useful for control of amounts of toxic vapors, gases, mists and dusts, and for such hygienic standards as threshold limit values (TLV) and maximum allowable concentration (MAC). The unit in which such concentrations are normally expressed is parts per million (ppm); that is, volumes of contaminant per million volumes of air. We use TLV as a guide in controling hazards to health—not as a fine line between safe and dangerous concentrations. The values are average concentrations over a normal workday exposure, day after day, without adverse effect.

Propellant fuels and oxidizers present a health hazard to using personnel. They are all toxic to some degree and, in some cases, may cause severe and lasting damage or even death. Physical contact, though only momentary, could produce damage to vital organs such as the liver, lungs, and kidneys. It must be understood that during all handling operations every effort must be made to avoid the mist, sprays, and vapors of these materials.

There are three methods by which harmful substances can enter the body. They are ingestion, absorption, and inhalation. Inhalation is the most common of the three. Another hazardous characteristic of some fuels is that they produce severe chemical and thermal burns upon gross contact with the skin. Cryogenic materials, such as liquid oxygen, can produce severe frostbite.

To better illustrate the effects of exposure, the health hazards associated with chlorine trifluoride are quoted: "The TLV is 0·1 partsper million. The

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objectionable odor, resembling mustard or chlorine, is found sufficient to warn of hazardous concentrations. Slight exposure to the vapor causes watering of the eyes, coughing and difficult breathing within a few minutes. Serious lung injury, resembling that due to phosgene, may result with increased susceptibility to pneumonia. Congestion of the lungs may occur during recovery. Kidney and liver damage may occur. The eyes may be permanently injured by high vapor concentration. High concentrations may result in death in a few minutes." Chlorine trifluoride has the ability to cause acute body damage and even death instantly; however, this is not always the case. Some propellants act in a more insidious manner, whereby serious damage occurs over a long period of time because of chronic exposure. For example, where there is repeated exposure to nitric acid fumes in low concentrations (25 ppm), it may cause ulcerations in the nose and mouth, wearing down and decay of the teeth, chronic lung damage and chronic irritation of the entire respiratory tract. It can be seen that a defensive plan of action is always necessary. Never take safety for granted; always wear adequate protective devices when you work with propellants, fuels, and oxiders.

The prevention of toxic poisoning and chemical burns involves:

- Engineering prevention to minimize spills and leaks and to insure adequate ventilation.
- Use of appropriate personnel and collective protection practices and equipment.
- Industrial hygiene surveys.
- Medical surveillance including periodic physical examinations.
- Medical treatment and preventive procedures.
- Education and supervision in hygienic procedures and first aid.

All operations that require handling of fuels and oxidizers should follow a predetermined plan. No one should be allowed in any area where these materials are kept in main, ready, or other storage unless he is accompanied by another authorized person, both being outfitted with all necessary protective clothing and equipment. One member of such a crew must be ready for immediate action with water hose, firefighting equipment, or other apparatus specifically required at the operation to control the effects of spillage.

Ventilation is important in preventing poisoning. Local exhaust ventilation is preferable to general ventilation because it controls contamination of air at the source. The choice between the two types of ventilation will normally be dictated by the nature of a specific operation.

The prevention of fire involves:

- Keeping the area free of combustible materials.
- Ventilating to keep vapor concentrations at a safe level.
- Fuels and oxidizers must be kept separated.
- Suiting the firefighting equipment and extinguishing agents to the probable type of fire.

The prevention of explosion follows generally the same principles applicable to eliminating and controlling fire hazards. In addition, earth, sand, concrete, or metal barricades of sufficient mass will decrease the effects of an explosion. Electrical installations normally should be explosive-proof, vapor-proof, and housed in rigid metal conduit. In all circumstances, the provisions of the National Electric Code will be followed. Access roads to all storage sites must be large enough to provide adequate turning space at each storage area. There must be at least two access roads, one of which will permit safe egress if a fire should occur at the storage site. With the exception of one oxidizer listed, all storage tanks must be surrounded by a dike high enough to hold 10 percent more than the maximum storage containers. Special precautions should be taken to keep storage areas free of all contaminating or combustible materials.

Exercises (238):

1. What type of propellant is maintained in separate units until the instant of firing?

2. The greatest hazards associated with liquid missile propellants are ______, ______, and ______.

3. What are the three methods by which harmful substances may enter the body?

4. What is the first sensory warning of chlorine trifluoride?

5. What is the minimum number of persons allowed in storage areas?

6. Electrical installations in liquid fuel storage must meet the provisions of the ______ ______ ______.

7. What must surround each storage tank?

239. State basic characteristics, hazards, and fire precautions for liquid oxygen.

Liquid Oxygen. Liquid oxygen (LOX), nitrogen tetroxide, and fuming nitric acid, are three of the more commonly used liquid oxidizers. Liquid oxygen is light blue, transparent, and has a boiling point of -297° F. Although it is not flammable by itself, it will vigorously support the combustion of other materials. LOX is "cryogenic," that is, it produces very low temperatures.

Hazards. LOX readily forms combustible and explosive mixtures when it comes in contact with most substances, especially those of organic origin. The explosive gels formed when spills occur are a major hazard. Their coldness can produce severe burns, resembling frostbite, on contact with the skin.

Storage. LOX is stored in well-insulated tanks to reduce losses from evaporation. Construction materials for such tanks must possess satisfactory physical properties at the low temperatures. The ability to withstand stress concentrations as a result of sudden temperature changes is another requirement. Neither corrosiveness nor reactivity is a factor. However, freedom from grease or dirt is extremely important.

Handling. Proper cleanliness, exhibited by greaseless dirt-free tanks and transfer lines, is essential to the safe handling of LOX. The critical temperature for oxygen is -181.8° F. This means that oxygen cannot be kept in a liquid state at a higher temperature regardless of the pressure. Hence, excessively high pressures may develop for liquid trapped between valves, in closed vessels, or in dead ends.

NOTE: When LOX is transferred from one vessel to another, the possibility of thermal shock should be reduced by first gradually cooling the receiver. Small spills are allowed to evaporate. Water spray is often used to hasten evaporation. Large pools of LOX should be treated cautiously to avoid creating new hazards by forming excessive quantities of gaseous oxygen.

Firefighting. Oxygen will not burn alone, but it supports combustion vigorously. When it is mixed with a fuel, two types of combustion may occur. If ignition occurs before or concurrently with mixing, a flare type fire develops. If mixing takes place first, no flame may develop; but upon subsequent ignition, or from mechanical shock, a detonation or explosively violent combustion will occur.

NOTE: Fighting fires around LOX centers involves cutting off the flow of oxygen or fuel. The usual smothering and blanketing agents are ineffective. In situations where fuel and oxygen are mixed but not burning, the areas should be isolated and the oxygen allowed to evaporate. Water dilution of water soluble fuels reduces the intensity of the fire. Water should not usually be used on large pools of LOX, as it hastens evaporation and aggravates the situation.

Disposal. The main method for disposing of LOX is by evaporation. When large quantities are involved, care must be taken that an additional hazard is not introduced by the presence of excessive gaseous oxygen. Special disposal areas, free of combustible materials, are usually established for this material.

Exercises (239):

1. What is the boiling point of LOX?

2. What does "cryogenic" mean?

3. A major hazard of LOX is _______ .

4. What is often used to hasten evaporation of liquid oxygen?

5. Fighting fires around liquid oxygen centers involves what action?

6. What effect do the usual smothering and blanketing agents have on fires involving LOX and fuels?

7. The main method of disposing of liquid oxygen is by _______ .

240. State the composition of nitrogen tetroxide, and give its dangers and requirements for special handling.

Nitrogen Tetroxide. Nitrogen tetroxide is actually an equilibrium mixture of nitrogen tetroxide and nitrogen dioxide. The mixture is a heavy brown liquid at room temperature as a result of the nitrogen dioxide content. The liquid gives off fumes that may vary from yellowish to reddish brown, depending upon the temperature. These fumes have a very pungent odor. The liquid is corrosive to the skin and the vapors are extremely toxic.

Hazards. The chief hazard to contend with in handling nitrogen tetroxide is the health hazard. The liquid is very corrosive to the skin and can cause severe burns. The fumes, if inhaled, can produce acute poisoning, evidenced by a filling of the lung spaces with fluid. Unfortunately this condition may not develop immediately. The TLV is 5 ppm for nitrogen dioxide or 2.5 ppm for nitrogen tetroxide. Nitrogen tetroxide by itself will not burn nor does it form explosive mixtures in air. It does form hypergolic mixtures with several fuels including the hydrazines, aniline, and furfuryl alcohol. Its vapors can form explosive mixtures with various fuels if they are confined.

Storage. Nitrogen tetroxide is stable at normal temperatures and can be stored without refrigeration. It is readily stored or transported in cylinders or tank cars. Most common metals can be used if the moisture content remains below 0.1 percent. Under wet conditions, where it is about as corrosive as 60 percent nitric acid, stainless steel is required.

Handling. Personnel handling nitrogen tetroxide during transfer or storage must wear approved protective clothing and respiratory equipment. Transfer facilities should be out of doors. The liquid may be transferred from tank to receiver by pumping or by use of dry compressed air or dry compressed inert gas. All equipment must be free of contaminating grease or dirt. Any spills must be washed down immediately with large quantities of water. Washings must be directed to a special disposal area.

Firefighting. By itself, nitrogen tetroxide will not burn. Mixed with a fuel it readily supports combustion. Mixtures of nitrogen tetroxide and the hydrazines, aniline, or furfuryl alcohol will ignite spontaneously. The chief problem in fighting fires involving this material is to avoid the toxicity of the fumes that are given off. Large quantities of water will dilute the oxidizer and hasten its evaporation. The diluted material will no longer support combustion.

Disposal. Because of the toxic nature of nitrogen tetroxide, special precautions must be taken in disposing of it. Small spills are washed down with large quantities of water to hasten their vaporization. The washings must flow to a special area where they can be neutralized or eventually burned. A limestone decontamination pit should be used. Care must be taken to keep the nitrate level in the disposal area at acceptable levels. Where large spills occur or contaminated off-grade material must be disposed of, the nitrogen tetroxide should be pumped into containers and transported to the disposal area for neutralization or burning. In disposing of the material, extreme care must be taken against being poisoned by either the liquid or the gases.

Exercises (240):

1. Nitrogen tetroxide is actually an equilibrium mixture of what two substances?

2. What is the chief hazard to contend with when handling nitrogen tetroxide?

3. When is respiratory equipment and protective clothing required involving nitrogen tetroxide?

4. What happens when nitrogen tetroxide and the hydrazines mix?

5. What effect does water have on nitrogen tetroxide?

241. State characteristics and dangers of fuming nitric acid, and give safety and fire procedures.

Fuming Nitric Acid. The fuming nitric acids are highly corrosive liquids varying from colorless to reddish brown, depending upon the content of dissolved oxides of nitrogen. The vapors possess a characteristic pungent odor. The type most frequently used at missile sites is inhibited red fuming nitric acid (IRFNA), which is the red fuming type with added hydrogen fluoride (HF) to reduce corrosion.

Hazards. The corrosive nature of these acids makes them capable of causing severe burns when they contact the skin. If splashed in the eye, the burns can lead to blindness. The fumes evolved from the acid (and from its reaction with organic materials) are toxic. The TLV for fuming nitric acid is 5 ppm based on nitrogen dioxide content. The acids will not burn by themselves. They will react vigorously with organic materials and are hypergolic with aniline and other amines. The fumes can support combustion. The nitric acids are stable to mechanical shocks and impacts.

Storage. Nitric acid is stored in specially prepared aluminum or stainless steel containers. Special precautions should be taken to keep storage areas free of all contaminating or combustible materials. Provision is needed for ample water to flush down any spills. The entire storage area should be provided with adequate drainage and a decontamination system. An earthen dike of sufficient height to contain all the stored material should also surround the storage tanks.

Handling. Because of the corrosive nature of the liquid and the toxicity of the fumes, all personnel handling the acids during transfer and storage must wear proper protective clothing and respiratory equipment. All spills must be flushed away with large quantities of water. All storage and handling equipment must be kept free of contamination. Protective transparent shields should be provided where danger of splashing or spraying of acid exists.

Firefighting. The nitric acids will not burn by themselves, but they do react vigorously with combustible materials. Sufficient heat can often be developed to ignite such materials. Nitric acid ignites spontaneously with aniline and certain amine compounds. The fire that develops is of the flare type. Its intensity depends upon the rate of mixing and quantities involved. To control fires, stop all flow of acid and fuel. Large quantities of water are effective for diluting the mixture and reducing its effectiveness as an oxidizer.

Disposal. In disposing of small quantities of the acids, dilution with water is generally sufficient. The wash waters are usually run into neutralizing beds of limestone. For large quantities it is desirable to reduce the evolution of fumes by spraying a water solution containing 70 percent by weight of sodium dichromate over the surface of the acid. At least one gallon of 70 percent dichromate solution is required per gallon of acid. This procedure is followed by flushing with large quantities of water. Any flushed surfaces can be neutralized with a 5-percent solution of sodium carbonate.

Exercises (241):

1. What type of fuming nitric acid is most frequently used at missile sites?

2. The acids are hypergolic with _______ .

3. When should protective transparent shields be provided in the use of acids?

4. What type fire develops when the acids come in contact with certain amine compounds?

5. How do we control fires involving acids and fuels.?

6. How is the effectiveness of acid as an oxidizer reduced?

242. Give physical characteristics, hazards, and fire precautions associated with alcohols used as fuels.

Alcohols. The alcohols, ammonia, the hydrazines (unsymmetrical dimethyl hydrazine), and the hydrocarbon fuels are examples of liquid fuels. The common alcohols are methyl, ethyl, isopropyl, and furfuryl alcohols. The methyl, ethyl, and isopropyl alcohols are all clear, colorless liquids. Furfuryl alcohol is amber colored. All have characteristic odors and are excellent solvents. All are reactive with oxidizers but furfuryl alcohol has the highest reactivity. They are all flammable fluids. Furfuryl alcohol is hypergolic with fuming nitric acid.

Hazards. The alcohols are all readily volatile. Methyl and isopropyl alcohol vapors are toxic, TLV for methyl alcohol is 200 ppm, for isopropyl is 400 ppm. The TLV for ethyl alcohol is approximately 1000 ppm. Furfuryl alcohol is toxic when ingested. Swallowing less than one-half pint of methyl alcohol can be fatal. Methyl, ethyl, and isopropyl alcohols will ignite at room temperature and burn with an almost colorless flame. Furfuryl alcohol has a relatively high flash point. The vapors of methyl, ethyl, and isopropyl alcohol form explosive mixtures with air. Vapors of furfuryl alcohol are less hazardous.

Storage. The alcohols are all readily stored in steel drums or tanks. Care must be exercised in avoiding spills. Spills that do occur should be washed down with large quantities of water. Storage areas should be diked to retain all the liquid from a ruptured tank. Good housekeeping is essential.

Handling. The normal procedures followed for flammable liquids are suitable for the alcohols. Plastic or rubber aprons are usually sufficient protective clothing. Where high vapor concentrations above the TLV limit are encountered, respiratory equipment must be used.

Firefighting. The alcohols are all flammable. However, methyl, ethyl, and isopropyl alcohols ignite at room temperatures while furfuryl alcohol has a relatively high flash point. The almost colorless flame of the alcohol is in marked contrast to fires from hydrocarbon fuels and poses a special hazard in detecting a flashback.

Fires involving the alcohols should be fought as class B fires. If foam is used, it should be of the alcohol-compatible type. Water fog, or carbon dioxide extinguishers may be used. Regular water streams are not effective because considerable dilution is needed to stop combustion. In the presence of oxidizers, dilution with large quantities of water may be the best method.

Disposal. Where necessary, large quantities of waste alcohol may be burned in properly selected, isolated areas.

Exercises (242):

1. Which of the alcohols is amber colored?

2. What reaction takes place when fuming nitric acid and furfuryl alcohol come into contact with each other?

3. What is essential in the storage of the alcohols?

4. Which of the alcohols will ignite at room temperature?

5. Fires involving the alcohols should be fought as what class of fires and what agents may be used?

6. Why are regular water streams not effective on fires involving the alcohols?

243. Tell how anhydrous ammonia is used and what safety precautions it requires.

Ammonia (Anhydrous). Anhydrous ammonia is a colorless liquid when it is below its boiling point (-28° F.). Its colorless vapors are characterized by a very specific pungent odor and are irritating to the eyes, nose and throat tissues. Ammonia is alkaline in nature and is very reactive.

Hazards. Ammonia is considered to be a toxic material (the TLV is 50 ppm). The liquid is corrosive to the skin. The vapors are very irritating when inhaled or when they come in contact with the eyes. The flammable range for ammonia-air mixtures is quite narrow (16.1 percent to 26.8 percent ammonia by volume). Although explosive mixtures can be formed when ammonia vapor is mixed with oxidizer, they are rarely encountered.

Storage. Anhydrous ammonia is relatively easy to store as a liquefied compressed gas. Steel containers are suitable, or aluminum can be used. Bulk storage facilities may or may not be refrigerated. Some protection should be afforded from direct sunlight, or relatively high pressure can be anticipated.

Handling. The handling of ammonia is relatively simple. Through long time usage, ammonia handling procedures have been well developed. Moderate protection is required for operating personnel; cotton clothing, splash-proof goggles, rubber gloves, and boots. Operating areas should be well ventilated.

Firefighting. Water from a fog or spray nozzle is effective in diluting liquid ammonia spills. Acid should not be used to neutralize liquid ammonia because the heat generated can easily generate considerable fumes. Ammonia fires supported by oxidizers are also readily extinguished with water.

Disposal. Liquid ammonia has a high solubility in water. It can thus be easily diluted. The diluted material is not considered harmful. In fact, liquid ammonia itself is used in considerable quantity as a fertilizer.

Exercises (243):

1. What effect do anhydrous ammonia vapors have on the eyes, nose and throat tissues?

2. Why should anhydrous ammonia storage containers be protected from direct sunlight?

3. What degree of protection is required when handling ammonia?

4. Why should acid NOT be used to neutralize liquid ammonia?

5. Anhydrous ammonia is also widely used for what purpose?

244. Give the properties of the hydrazines that most directly affect firefighting.

Hydrazines. Two members of this family are used as missile fuels; hydrazine and unsymmetrical dimethyl hydrazine (UDMH). Both are clear, colorless, hygroscopic (readily taking up and retaining moisture) liquids with the odor of ammonia. They are similar in properties except that UDMH has a much lower freezing point (-72° F. versus 36° F.) and is somewhat more stable thermally. Neither is shock sensitive.

Hazards. Both of the hydrazines are considered toxic. Several significant systemic effects may be produced from exposure by inhalation, ingestion or direct skin contact. Hydrazine is believed to be slightly more toxic (TLV = 1.0 ppm) than UDMH (TLV = 0.5 ppm), but the latter is more highly volatile. Both are flammable in air over a wide range of concentrations. Hydrazine can serve as monopropellant; therefore, it can burn in the absence of air. They are both hypergolic with fuming nitric acid. Neither fuel will burn when diluted with about three times its volume of water. Although the liquid products are insensitive to shock or friction, the vapors can be exploded by a spark or flame.

Storage. The hydrazines are stored in a variety of drums and tanks. Hydrazine requires special grades of stainless steel or aluminum, but UDMH is usually shipped in mild steel drums. Because of the explosive nature of their vapors, both materials must be stored and handled under an atmosphere of nitrogen at all times. All storage areas must be well ventilated.

Handling. Special precautions must be taken in handling these fuels because of their toxicity and the flammable and explosive characteristics of their vapors. Whenever there is danger of a spill, respiratory equipment must be worn, since the detectable odor is well above the TLV level. Normally face shields, rubber aprons, rubber boots, and vinyl gloves are satisfactory protection. Operating areas should always be well ventilated.

Firefighting. Two types of fire hazards exist–fuel fires or fuel-and-oxidizer fires. Water is the most effective agent for combating the fuel fires. It cools as well as dilutes the fuel. Mixtures of three parts of water to two parts hydrazine or of three parts water to one part UDMH will not burn. The wide range of the flammable limits for these materials with their reignition hazards make vaporizing liquids, foams, and powders less effective than water dilution. If water fog is used, large quantities must be applied in order to obtain the required dilution effect and to prevent reignition. CO^2 may not be used, as it is reactive with hydrazine. Water is most effective for the flareup fuel-oxidizer fires where it is compatible with the oxidizer.

Disposal. Spills involving the hydrazines are best disposed of by flushing with large quantities of water. Drainage areas must be well ventilated. Where the quantity needing disposal is large, it can be burned in quantities of not more than 1000 pounds each in a shallow earthen depression completely isolated from any storage or inhabited area. Respiratory equipment must be worn by all operators performing the disposal.

Exercises (244):

1. What do we mean when we say that the hydrazines are hygroscopic?

2. Which of the hydrazines is more highly volatile?

3. How many gallons of water would be needed to dilute 50 gallons of either of the hydrazines?

4. The hydrazines are most dangerous as a _____.

5. What effect does water have on hydrazine fuel fires?

6. If it is compatible with the oxidizer, what agent is most effective for flareup fuel-oxidizer fires involving UDMH?

245. Give the basic firefighting precautions for hydrocarbon fuels.

Hydrocarbon Fuels. There are a number of petroleum fractions that we use as fuels in missiles. These range from the high-boiling kerosenes (e. g., JP-5 and RP-1) through the wide-cut kerosene-gasoline mixtures (e. g., JP-4) to the highly volatile aviation gasolines. They are all clear liquids ranging from colorless to pale yellow unless purposely colored for identification purposes. They are all flammable and their vapors form explosive mixtures in air.

Hazards. Outside of special situations, such as in the case of large spills in poorly ventilated spaces, the hydrocarbon fuels are not particularly toxic. Such toxicity as does exist increases with aromatic content. The amount of lead in leaded gasolines is so small that a lead hazard does not exist under normal handling procedures. Because of their flammability, all of these liquids represent a fire hazard. Each of the fuels has different limits of flammability. Normally (JP-4 is an exception), in a closed container their vapors are too rich to ignite. Thin films can generally be ignited by a flame. The vapors also form explosive mixtures with air which can be readily ignited by a spark or a flame. When they mix with oxidizers, the mixtures (both liquid and gas) can be exploded by shock, by heat, by spark, or spontaneously.

Storage. The hydrocarbon fuels are readily stored in steel drums or tanks of all sizes and shapes. Storage tanks must be suitably protected. Storage areas must be kept neat and free of debris.

Handling. As long as there are reasonable precautions to avoid spills, handling hydrocarbon fuels is not difficult. An adequate water supply should always be available for washing down spills. Protective clothing requirements are usually limited to neoprene aprons, gloves and boots. Respirators may be required for fuels with high aromatic contents.

Firefighting. Three types of fires are encountered with hydrocarbon fuels: spill fires, tank or pool fires, and flowing fuel fires (e.g., from a ruptured line). Firefighting methods are the same as those used for extinguishing class B fires. Foam, water, fog, and CO^2 may all be used as extinguishing agents. Foam and water fog are effective for fires involving the more volatile fuels. Water fog is also used for fires involving mixtures of fuel and oxidizer. Extreme care must be taken when LOX is present to avoid formation of gels.

Disposal. Spills of hydrocarbon fuels may be absorbed in sand or dirt or flushed down with water. Drainage for such washings should not enter pipes or inclosed spaces where an explosive situation can develop. Drains should lead to an isolated area to avoid the hazards of ignition. Larger quantities of unwanted fuel can be burned in a special isolated burning area.

Exercises (245):

1. Why are hydrocarbon fuels colored (dyed)?

2. What increases along with the toxicity of hydrocarbon fuels?

3. What three types of fires are encountered where hydrocarbon fuels are used?

4. Why must extreme care be taken when LOX is in the presence of hydrocarbon fuels?

5. How may spills of hydrocarbon fuels be disposed of?

7-2. Solid Propellants, Igniters and Special Devices

Solid propellants have been used for propulsive purposes for a long time. It is only recently, though, that they have found application in large missiles and space vehicles. To store and handle solid propellants safely, we must understand their susceptibility to ignition, sensitivity to shock or impact, and general storage stability. Solid propellants may be loaded at the propellant manufacturer's plant, arriving at the launch site as an integral part of the missile structure. Thus, the propellant is protected from direct contact with exterior factors. A missile uses a wide variety of igniters and special devices, many of which contain flammable, explosive, or pyrotechnic materials that ignite spontaneously in the air. Liquid-propellant rockets may use igniters that contain such pyrophoric liquids as trimethyl and triethyl aluminum. Solid-propellant rockets have igniters containing a variety of propellant and pyrotechnic materials. Special devices such as tracking flares, destruct units, explosive bolts, and explosive-operated cable cutters are also common to a missile site.

246. Give the physical characteristics of solid propellants, tell how they are shipped and used, and cite the hazards associated with them.

Solid Propellants. Even though you as a firefighter are not expected to come into direct contact with solid propellants, you will be concerned with the loaded missile. There is always the possibility of a malfunction on the stand which will leave unburned solid propellant that must be properly disposed of.

Solid propellants, in general, are solid, plastic-like materials with a wide variety of physical characteristics varying with type from very rubbery and semi-rigid to very rigid. Temperature has a decided effect on their properties. Low temperature (-40° F.) makes them brittle while high temperature (+140° F.) makes them soft. Their color can extend across the spectrum because of the variety of additives used in their preparation. The autoignition temperature varies from about +250° F. to +350° F.

Solid propellants are fabricated into so called charges or grains possessing a variety of geometric shapes, but the most common is cylindrical. The outer surface of such cylinders is usually bonded to the rocket chamber wall. The cylinders are perforated axially so that burning can take place on the exposed inner surface. To control the rate of total gas evolution, the internal perforation is made in a variety of geometric shapes.

Generally, solid propellants will not be received at launch or test sites in any way other than as an integrated part of the missile. The propellant will always be sealed within the rocket motor and as such will be protected from most external hazards. Fires could only start from (1) decomposition of the propellant or (2) malfunction of the ignition system. The missile could be endangered if a fire developed in the surrounding area. Improper handling of the missile during transfer could result in physical damage to the propellant charge and then could lead to a malfunction on the stand resulting in an explosion or launch failure.

Although solid propellants will probably not be handled separately, their very presence in a missile constitutes a hazard. Solid propellants are classified as explosives by the Department of Transportation and other authoritative groups. These propellants normally burn by means of an orderly decomposition process, but some can detonate under certain conditions such as an increase in temperature or shock. Consequently, the missile and its propellant constitute the source of a fire hazard, explosive hazard, and fragment hazard. Solid propellant systems are relatively simple in comparison to the liquid systems. They are placed—during the manufacture of the missile motor—in a case in the location where they will burn. This eliminates problems of fuel transfer, tankage, pressurization, flow control, and leakage. The rocket motor is simple in construction, and the propellant is usually contained as a single mass or "grain," which burns on all exposed surfaces. Normally, the ignition system does not come with the missile but is shipped and stored separately.

Solid propellants have been used for propulsion purposes for a long time. It is only recently, though, that they have found application in large missiles and space vehicles. Solid-fuel engines now propel (all stages) the Minuteman and the Navy Polaris. In addition, two large solid-fuel engines are to be part of the first stage of the Titan III. The use of solid fuel in missiles of the IRBM and ICBM class is comparatively new. For years, this area of missile propulsion has been the domain of the liquid-fuel engine. Solid-fuel engines also propel air-to-air missiles such as the Sidewinder, Genie, and Falcons.

Although liquid and solid propellants may not differ greatly as to ease of ignition, sensitivity to shock or impact or general storage stability, they do require considerably different handling and storing procedures. Liquid propellants are stored in tanks, drums, or cylinders and are loaded into the missile usually just before firing. On the other hand, solid propellants may be loaded at the propellant manufacturer's plant, arriving at the launch site as an integral part of the missile structure.

Basically, there are two types of solid propellants. The first type contains a fuel and an oxidizer, neither of which would burn satisfactorily without the other. The oxidizer, such as potassium perchlorate or sodium nitrate, is mixed with a fuel which can be easily oxidized. These fuels may be such substances as charcoal, asphalt, or ammonium picrate, to name a few. This type of mixture is often referred to as a *composite* propellant. The second type contains unstable chemical compounds which are capable of combustion by themselves. In this type, the ingredients are in a *colloidal* state; that is, the ingredients consist of extemely small, finely dispersed particles. Propellants of the collodial type are usually semitransparent and have sort of a plastic consistency. In the manufacture of colloidal propellants, two of the major ingredients commonly used are nitrocellulose and nitroglycerine. If the propellant contains both of these ingredients, it is referred to as a double-based propellant. Most rocket motors of the colloidal type are double-based—for example, ballistite, which is the propellant used in the 2.75-inch aircraft rocket. An example of a single base would be gunpowder, which traditionally has been based on either nitrocellulose or nitroglycerine.

The compounded chemicals we have discussed should be considered as the principal ingredients. However, most solid propellants contain anywhere from four to eight other ingredients. These additives are used to build specific characteristics into the solid propellant. For example, a double-based propellant using only nitroglycerine and nitrocellulose would not be suitable for use in rocket motors, so certain additives must be put in to achieve the desired ballistic properties.

Solid propellants should not be stored outside the propellant chamber at any test or launch site. Storage is generally in barricaded, specially constructed storage buildings located in isolated areas. Quantity-distance tables govern the distances between structures. Solid propellants are rarely handled outside of sealed shipping or transfer containers. For fire inspection purposes, the storage requirements for explosives and propellants are based upon the relative fire and explosion hazards involved. For purposes of classification as to hazards, these propellants are divided into classes and groups in the same manner as munitions and explosives.

The main hazard associated with solid propellants concerns their relative ease of ignition by a flame or spark. When they are stored in sealed containers, this hazard is very small. Solid propellants normally burn in an orderly fashion; some can be detonated. Once these propellants begin to burn, the fire will spread rapidly over all exposed surfaces. Burning results in large quantities of very hot gases (about 5000° F.). All firefighting activities should be conducted according to the fire symbol group involved. Most of these propellants are not outwardly toxic themselves; however, the gases evolved in the burning of many compositions are toxic.

Some solid propellants can be ignited by shock, impact, or friction, depending upon the conditions. Because it has not been completely proven that all solid propellants are insensitive to such forces nor that they will not detonate, many are considered as explosives. The classification of the particular propellant used in a missile will be indicated in the appropriate manual for that missile.

Exercises (246):

1. What effect does temperature have on solid propellants?

2. What is the most common shape solid propellants are fabricated into?

3. How is the rate of total gas evolution controlled in solid propellants?

4. How is the solid propellant in a rocket motor protected from most external hazards?

5. How are solid propellants classified by the Department of Transportation?

6. How are most of the solid propellants that you will encounter used?

7. What are the two basic types of solid propellants?

8. What ingredients must be used in a solid propellant for it to be known as a double-based propellant?

9. What is the purpose of the additional ingredients added to the principal ingredients in solid propellants?

10. What governs the distances between buildings used for storage of solid propellants?

11. What is the main hazard associated with solid propellants?

12. Why are solid propellants considered as explosives?

247. State the basic fire considerations for igniters and special devices.

Igniters. There are essentially two types of igniters used in liquid-propellant rockets: electrical and chemical. The electrical igniters consist of spark or glow plugs, which pose no particular storage or handling problems. The chemical units (chemical heat producing) are much more dangerous. The pyrogen igniters used for solid-propellant rockets usually consist of an electrical initiating element surrounded by some pyrotechnic material. The complete assembly is packaged by the manufacturer in a metal or plastic container to provide protection from moisture and other exterior factors. These devices are stored separately from the missile until time for final assembly on the launch pad. Because the initiating element is electrical and operates as a high-resistance circuit (hot wire), there is always the possibility of accidental ignition from any pickup of stray electrical impulses from radio frequency (RF) currents such as are generated by radio or radar systems. These initiating elements are always shunted (shorted across) until they are assembled on the pad, and shielding is also provided to prevent accidental ignition. Aside from this, and the continuity testing of igniter circuits, there are relatively few specialized storage and handling problems associated with these devices.

The chemical-type igniter can operate in several ways. It can use a separate combustion chamber to initiate a flame by using a monopropellant, which contains all elements necessary for combustion, and an electrical igniter. It can use a liquid that is hypergolic with one of the components of the main propellant system; or a liquid such as triethyl or trimethyl aluminum, which ignites spontaneously when exposed to air. Chemical igniters are normally made up at the factory and shipped as sealed units because of their extremely high reactivity. These units consist of metal cylinders filled with the chemical and sealed at each end with metal diaphragms. The cylinders are placed in the missile in the fuel feedline or in a special bypass line. When pressures are applied to the lines for a launch, the flow of fuel causes the diaphragms of the igniter to rupture. The chemical slug enters the combustion chamber at the same time as the oxidizer, insuring combustion.

Special Devices. Signal flares, explosive bolts, cable cutters, and other pyrotechnic items are very dangerous and deserve ample consideration during fire inspections. Certain basic storage procedures are followed, such as avoiding excessive heat and isolating from other materials. These items should be handled with a healthy respect for the potential power they contain. One of the few fatalities resulting from missile launch was caused by accidental discharge of a flare system as a missile was being checked out on the launch pad.

The handling and storage requirement for these igniters and devices will normally follow the safety criteria established for operations involving explosives or explosive components. The only materials in igniters that require special firefighting precautions are the pyrophoric alkyl-aluminum compounds. Trimethyl and triethyl aluminum are so reactive that water, foam, or water fog *cannot* be used for fighting this type of fire. Dry sand or special dry-chemical extinguishing agents and carbon dioxide can be used on small fires, but re-ignition may occur. High-boiling hydrocarbons may be used as diluting agents and will serve to cut down reignition.

There are no special techniques that can be suggested for handling fires involving these special devices. Usually the units are oneshot devices and the damage has been done before the fire department can reach the scene. Should there develop a need for disposal, it should be carried out only by qualified explosives ordnance disposal personnel.

Exercises (247):

1. What are the two types of igniters used in liquid-propellant rockets?

2. Of the two types of igniters, which is the more dangerous?

3. Why are chemical igniters normally shipped in sealed containers?

4. Which of the special devices are pyrophoric.

5. What agents may be used as diluting agents for the pyrophoric aluminum compounds?

7-3. Launch Site Operations

The problems associated with fire protection are intimately associated with the type of missile or rocket being launched or tested. This unit presents the characteristics common to most sites and, some of the differences between sites. This unit also places attention on those elements that affect fire protection at missile sites.

248. State the basic fire considerations presented by general launch and test site characteristics and systems.

Launch and Test Site Characteristics. All launch sites, whether they are test or operational, contain many common hazards. For example, they contain fuels, oxidizers, starting devices, electrical systems, and people. Before progressing further, let's review what makes up a launch site complex.

Launch pad. The launch pad consists of a well-reinforced concrete pad to which is attached the missile mount, instrument control cable, and necessary utilities.

Ready storage facilities. These are storage areas that are located as close as practical to the launching area. In general, they contain only the amount of propellant needed for each test or launch. Only liquid propellant is stored in ready storage facilities, because solid propellant rocket motors are loaded at the manufacturer's plant.

Blockhouse. The control for the launch area is directed from a centrally located, reinforced concrete structure known as the blockhouse. The blockhouse houses banks of electronic instruments used to observe and check the missile before, during, and after launching.

Fallback area. This area is located at a prescribed distance from the launch pad. This distance must be determined for each particular missile or missile complex.

Bulk storage area. The major quantities of propellant materials for use in missiles are stored in the bulk storage facilities. Fuels and oxidizers are stored separately because of their incompatibility. The liquid propellant bulk storage areas can be expected to contain the following facilities: drum storage; tank farm (diked); tank trucks; tank car (RR); and LOX storage. The storage of solid propellants at missile sites is limited to loaded motors. Barricaded magazines of various designs are used to store these. Igniters, squibs, and booster bottles are stored separately.

Other structures. The missile base may also contain a variety of operational and service buildings. These may include office buildings, barracks, dining halls, etc.

Test and Launch Site Systems. At some of the sites, both static tests and launch operations are carried out. This is particularly true where research and development activities are undertaken. The main difference in these sites is the operation rather than the layout or structural details. The fact that testing is done means that a greater variety of new propellants, new missiles, and new techniques are being studied and used. As a consequence, a test site is exposed to a greater fire hazard than is a site operated strictly as an operational launch facility.

Hard and soft sites. Operational sites are considered "soft" if they are constructed above ground where they are vulnerable to enemy attack. Sites constructed underground are considered reasonably safe from air attack and are, therefore, called hard sites.

Wet and dry stands. When a stand is constructed so that large quantities of water flow over the flame deflector to cool it during firing, the stand is known as a wet stand. Stands without water cooled deflector plates are called dry stands. The copious use of water for cooling purposes at wet stands is important to the fire organization, particularly if the water for cooling and the water for fire protection are from the same source or use the same distribution system. Fire protection personnel should be familiar with the design of the distribution system to prevent depletion of the supply of water for firefighting.

Exercises (248):

1. What hazards do test and operational launch sites have in common?

2. How much propellant is stored in the ready storage facilities?

3. Why is the fire hazard usually greater at a static test site than at a launch site?

4. What are "soft" sites?

5. State the difference between wet and dry stands.

6. Why should fire protection personnel be familiar with the design of the water distribution system?

249. Tell what basic factors govern water supply and distribution at operational sites.

Water Supply and Distribution. The most common fire extinguishing agent is water. Therefore, an adequate supply and distribution of water is critical. Water requirements will vary with different types of operations.

Wet stands. The size and nature of the operation determine the water supply requirements. When a wet test (or launch) stand is used, a minimum of 20,000 to 30,000 gallons of water is required per minute for the flame bucket alone. In some cases, 500,000 gallons of water have been used when stands involved in fire or mechanical failures prevented cutoff of the flame bucket cooling water supply. This illustrates the desirability of separating the firefighting water supply from the bucket cooling water supply and always maintaining a reserve supply of water. We have sufficient experience in the operation of both test and launch stands to approximate the water requirements and correct any mechanical deficiencies in the supply system. Elevated fog and spray nozzles placed around the base of the missile provide protection against incidental fire before and after the test or launch. When missiles are covered by retractable roofs or when the missile is fueled or defueled in a horizontal position, heavy spray nozzles mounted along the walls of the shelter can provide a complete deluge coverage for the missile. At hard sites where the missile is stored and fueled or defueled in underground silos, it is the practice to ring the silo with water spray nozzles at various levels.

Fire hydrants. Fire hydrants at the stand area should provide an ample supply of water for fire, for standby purposes, and for replenishing depleted water tanks on firefighting vehicles. The hydrants should be well away from the launch stand, usually at the edge of the pad area or on access roads. They should not be located down grade of the missile, because they could be cut off in the event of a serious spill.

Hose reels. Preconnected hose reels with 100 or more feet of 1½-inch hose can be used effectively for washdowns of minor spills or fires.

Exercises (249):

1. What determines the water requirements at sites?

2. Why should there be separate water supply systems for firefighting and bucket cooling?

3. How are missiles stored in underground silos protected?

4. What may happen if fire hydrants are located down grade from a missile?

250. State general requirements for firefighting equipment at missile/space launch sites.

Firefighting Equipment. The fire organization at missile/space vehicle launch sites must provide emergency and essential standby fire protection services. Assigning the proper number and type of equipment and personnel, including realistic distribution of equipment and personnel, will make the job much easier. In this section, we will discuss the use of firefighting equipment, including extinguishing agents, portable fire extinguishers, and auxiliary equipment such as that used for personnel protection.

Firefighting vehicles. The requirements for firefighting vehicles at launch sites will vary according to the nature of the operation. The greater requirements may occur at research and development sites where both test and launch facilities are present. At operational sites involving a limited number of missile launch stands and at hardened sites where the missiles are stored or launched from underground silos, firefighting vehicles will not be required.

Firefighting vehicles, manned by trained crews, provide a certain flexibility of operation. Their mobility provides protection and access to areas that may not be covered by the fixed systems. In the event of a major fire on the stand, the fixed systems will provide the best means of protecting the launch structure and washing away the propellants. The vehicles supplement the fixed systems, usually using water unless the propellants involved are reactive with water. In that case, the spills should be allowed to evaporate.

Firefighting vehicles have proved effective at missile/space vehicle test and launch sites. The primary purpose of this equipment is for emergency use. Vehicles must be ready to deliver maximum capability when called upon. Their use must be reserved for essential standby services (exceptionally hazardous operations).

Rescue vehicles for the rescue of personnel in the event of accidents is essential to fire protection. The increasing use of underground launch facilities places additional emphasis on the need for rescue in the event of malfunction of safety devices and equipment within the underground installation.

Extinguishing devices. Fire extinguishing devices used at missile/space vehicle test and launch sites are fixed systems, firefighting vehicles, and portable fire extinguishing equipment.

Fixed system on stands. Water is sometimes provided on stands, as indicated previously, to wash away propellant spills and to cool functional areas of the launch facility. Large quantities of water are needed in the form of water fog, spray, or straight stream, depending upon the item to be protected. This water is used to:

a. Provide cooling for superstructure elements that may be exposed.

b. Force heat away from parts of the missile that might otherwise be exposed.

c. Provide cooling for the area around the base of the missile and thereby minimize damage on launch.

d. Control fires within the engine compartment by directing streams upwards and under the lower skirt of the missile.

e. Reduce heat exposure to concrete pads.

f. Flush spills into drains or sumps.

The specifications for the installed water systems on the stand depend on the requirements of a particular launch complex.

When missiles are stored in underground silos, concentric spray rings around the walls of the silo are sometimes provided. Where missiles are stored and serviced in a horizontal position within a removable shelter, it has not been the general practice to provide a fixed deluge system within the shelter unless the missiles are also fueled in that position.

In service rooms adjacent to or under the pad, or in launch shelters, there is sometimes an automatic carbon dioxide flooding system. This is of such capacity as to completely inert the air space within the area protected. Fixed foam installations are similarly used where fuel rather than electrical equipment is involved.

Fixed foam systems are not usually installed on pads, but foam can be effective in controlling fuel spills. Carbon dioxide and dry chemical extinguishing agents are not used extensively for launch facility fires, since, unlike aerospace vehicle firefighting, there is usually no need for a quick knockdown. The hazard of flashback is a serious limitation in the use of these agents.

Portable fire extinguishers. It is most important to control and extinguish incipient fires before they reach major proportions. This often can be done with hand hose lines and portable fire extinguishers. To be effective such equipment must be of the proper type, carefully maintained, and used intelligently. If they are properly located, 1 ½" hose lines mounted on reels are preferable to portable water-type fire extinguishers.

Recognized vaporizing-liquid-type extinguishers are useful where electrical equipment is involved. As always, you must be careful to avoid the effect of fumes when you use such extinguishers in confined spaces. Carbon dioxide extinguishers are particularly adaptable for use at test and launch stands. They are your best weapons for fires involving electrical components in missiles. Portable fire extinguishers should be located in the immediate hazard area and in a position so that the operator will not be cut off from the exit path while using the extinguisher. In an enclosed space, the extinguisher should be mounted near a door and marked so as to be clearly visible. You must then insure their effective use by periodically training the operating personnel to use them properly. Be sure to take particular care in inspecting hand lines and hose reels, since operating personnel at launch sites sometimes use this equipment without due regard to its intended purpose.

Auxiliary equipment. A full complement of authorized accessories, appliances, and devices is essential. These would include such items as fire hose, nozzles, emergency rescue equipment, etc. Authorized protective clothing should be used in combating fires and for standby operation where there is excessive heat or chemical hazards. Be sure all personnel know the location of emergency showers and emergency eyewash stands. Self-contained breathing apparatus must be available for the more hazardous standby operations and for firefighting operations where there is a possibility of oxygen deficiency or toxic fumes. First aid kits should be available to assist rescued personnel or injured firefighters until medical service can be obtained.

Maintenance of equipment. No responsibility of fire protection activity is more important than the proper maintenance of all equipment. Achievement of the full firefighting capability depends on prompt action. Delays caused by equipment failure can mean the difference between minor damage and heavy losses – and they can result in the loss of lives.

Exercises (250):

1. Firefighting vehicles are not required at what locations?

2. In the event of a major fire on a missile

stand, what is the best means of protection?

3. Where are fixed foam installations provided?

4. What causes a serious limitation in the use of carbon dioxide and dry chemical extinguishing agents for launch facility fires?

5. We should insure the effective use of extinguishers by ____.

6. When is self-contained breathing apparatus worn at launch sites?

251. Tell what the functions of a fire organization at a test and launch site are; their importance; and when and how they are accomplished.

Firefighting and Rescue. Effective fire protection at missile/space vehicle test and launch sites requires men, equipment, training and know-how. This section outlines the nature of fire protection problems at missile sites, and it lists techniques for getting maximum effectiveness from the capabilities present. The subjects covered are functions, objectives, preplanning, standby operations, test and/or launch operations, and accident analysis. This section should give an understanding of what is expected of fire protection personnel at such locations, and should provide a basis for applying the broad concepts of fire protection to various types of missile sites.

Functions of fire-protection personnel. The functions of a fire organization at a missile or space vehicle test or launch site must be well established. In addition to the general responsibilities for structural firefighting, aerospace vehicle firefighting, and rescue; responsibilities include:

a. Certain standby fire protection for recognized exceptional hazard operations preceding test or launch.

b. Control and extinguishment of fires involving facilities, missiles, or space vehicles.

c. Personnel rescue as may be required.

d. Fire prevention inspection, preparing fire hazard inspection reports and necessary maintenance of fire protection equipment.

The range of functions at a particular site will depend upon the nature of the operation. Where the site is surrounded by heavily wooded terrain, for instance, preburning and forest or brush fire control will minimize exposure hazards.

Preplanning. The importance of careful preplanning of fire protection operations cannot be overstressed. No feature of the fire protection program can do more to assure effective use of men and equipment than a review of simulated drills in anticipated problems before an emergency develops. Through preplanning we can anticipate the nature of the problem at a given site, develop a program of coordination with related services, establish optimum plans for assignment of men and equipment for various types of operations, determine which areas need more intensive training, and resolve new problems. Preplanning should cover:

a. Basic procedures for emergency response.

b. The number, type, configuration, and general operation of missiles or space vehicles and their stands.

c. The layout of the launch site area, including access roads, terrain features, water supplies (both installed systems and hydrant installations) and the number, type, and location of support facilities.

d. The location and layout of bulk, and ready propellant storage areas and the hazards of the stored materials.

The exact nature of the relationship between the fire department and other support services will be established in preplanning sessions. The fire department must know what other support services are available and the extent of their availability. A close working relationship with missile safety personnel is of primary importance. Likewise, it is important to know who is responsible for the operation of such utility services as providing water and electricity, stopping fueling or defueling operations, providing medical services, and getting heavy equipment for rescue operations.

Standby operations. The hazardous operations requiring standby can be predetermined within reason, and personnel and equipment can be assigned accordingly. Periodic review of these standby operations on the basis of actual experience allows us to correct deficiencies in such programming and reassess the need for the standbys.

The development of men and equipment for required standby operations can be expedited using sketches or charts that show the respective position of vehicles, charged hand lines, fire extinguishers, and the number of personnel at each point. Supplement such visual aids in the assignment of duties with a typed list of the requirements for each operation, showing procedures and instruction for fire organization personnel that are expected to be present. These instructions will help to minimize any confusion that might develop during standby and will establish a basis for coordinated action on the part of all emergency personnel.

The plan for each type of operation should establish the *most effective* use of personnel and equipment for standby procedures. Enough flexibility must be maintained, however, to permit the officer in charge of the fire organization to adapt the plan to fit a particular situation. Ability to form such judgments will, to a large extent, determine the effectiveness of the fire organization.

In responding to a call for standby service, the officer in charge of the fire organization should immediately size up the situation and start the required procedures. In most instances the fire organization will be called by the missile safety officer and must work closely with him. Communication channels should be checked immediately upon reporting for standby so that in the event of emergency, additional assistance may be called without delay.

On any standby operation, the officer in charge of the fire organization must consider the particular operation in relation to other possible hazardous operations and the presence of combustible materials in the area. He must also check the number of persons working on the stand with a view to most effective withdrawal or rescue in the case of accident. Where fueling or defueling is involved, he must consider any temporary construction or operational procedures and equipment that might affect normal drainage or washdown of spills. Selecting hydrants and laying lines should take into account the location and drainage of possible spills. Men and equipment should be positioned so that they would not be cut off from escape or otherwise immobilized in the event of an accident. Wherever possible or practicable, it is better to use charged hand lines for standby purposes than to commit vehicles.

Assuming proper sizeup of the particular operation and the availability of men and equipment to meet the specific procedures, the action during an emergency should be routine. Of course the fire organization officer in charge must be in a position to follow the entire emergency operation and judge when withdrawal or change in tactics is required.

Test or launch operations. With one exception, the procedure outlined under standby operations above is generally applicable to test and launch operations. In launch operations the stand is cleared, operating personnel have withdrawn to the blockhouse, and emergency personnel and equipment are withdrawn to fallback areas. The standard fire protection operating procedures should be developed for each type of operation, specifying the number and classification of personnel, the number and type of firefighting equipment, the number and size of hose lines to be preconnected on the pad, and the nature of other emergency services to be present.

Prearranged signals from the missile safety officer must indicate the time at which all emergency vehicles must withdraw to the fallback area. Similarly, the missile safety officer must indicate when and which of the emergency services will be called into the area after test or launch. Under most circumstances, static tests on launch stands will be conducted on wet stands, and emergency services will not be required.

On dry stands used for launch, the missile safety officer will call the fire department to extinguish fires occurring in airconditioning ducting, insulation, and minor fuel spills. Hot metal parts of the launch stand may require cooling. This requires care to avoid excessive stresses caused by too-sudden cooling of the metal.

The most severe fires on stands develop when fuel and oxidizer tanks on liquid-propelled vehicles become involved because high-pressure lines or valves failed or the missile itself toppled. In such an event, the fire department will not be called nor will respond until the danger of explosion or detonation is lessened so that firefighters are not unnecessarily exposed to these hazards. Also, the capability of fixed water systems on and about the pad are greater than the capability of the fire department for controlling this type of fire. Should failure in fixed water systems occur, the fire department may be called to protect elements of ground support equipment and to wash down excess fuel. The proper use of water fog can reduce heat exposure to personnel and equipment. Turret or deluge nozzles are more effective under such conditions.

Under these circumstances, care should be taken to prevent unnecessary hazardous exposure of personnel and equipment. Propellant tank ruptures have occurred with explosive force, throwing burning propellant and shrapnel-like fragments for some distance.

The missile safety officer is responsible for calling in the fire organization, but once on the site, the officer in charge of the fire organization is responsible for the actions of his crew and equipment.

Postlaunch operations. After a successful launching, the fire organization normally is called in by the missile safety officer. Their function at this time is to extinguish incidental fires and to wash away any propellant spills.

Critiques and postaccident analyses. After every major operation on the pad, a critique is usually held. A fire organization representative should attend to obtain results of fire protection operations, to eliminate deficiencies if possible, and to improve operations if possible. Such critiques are particularly important after major accidents when full capabilities of the department have been utilized.

Exercises (251):

1. What would you do to assure the effective use of your men and equipment at a test and launch site upon assuming duties as a fire chief?
2. Why should you conduct preplanning sessions at a test and launch site?
3. Of what value are periodic reviews of standby operations at test and launch sites?
4. What should the plans for each operation at a test and launch site establish?
5. How flexible should the preconceived plans at a test and launch site be?
6. On a standby operation, why must you use caution in selecting a site to position your men and equipment?
7. As the fire officer in charge at a standby, how should you position yourself should an emergency arise?
8. How does the firefighters' role during a test or launch differ from their role during a standby operation?
9. Under most circumstances, when will emergency services not be required on launch stands and for what reasons?
10. When do the most severe fires occur on a test stand?
11. Why aren't firefighters normally called in as soon as a liquid-propelled missile topples on a test stand?
12. As the senior fire officer in charge, when would you assume responsibility for the actions of your men and equipment at the scene of a missile pad accident?
13. When are post accident analyses and critiques of particular importance to a fire organization?

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Aircraft Arresting Barriers

THE PURPOSE of aircraft arresting barriers is to stop aircraft safely which, for any reason, would otherwise run off the end of the runway during a landing or an unsuccessful takeoff. The primary purpose of an aircraft arresting barrier is to save the lives of pilots. The secondary purpose is to prevent damage to the aircraft and to the landing facilities.

The information in this chapter on aircraft arresting barriers cannot, of course, replace technical orders published for various barriers, but it will give you enough detail to understand the basic principles. For this reason, you should also study the applicable technical orders. You will find aircraft barriers listed in TO 35E8-2 series publications.

8-1. Barrier Configurations

There are many different types of aircraft arresting barriers in use by the Air Force. Some of these units are simple, while others are complex. Regardless of the type, aircraft arresting barriers have the same purpose – to save the lives of pilots and prevent damage to aircraft and the landing facility.

252. Give the basic aircraft barrier capabilities and limitations, and tell now they are measured.

Barrier Capabilities. An aircraft barrier usually is designed by the manufacturer to arrest a certain type of aircraft. Some barriers can arrest only aircraft equipped with hooks, while others will arrest those not equipped with hooks. Some may arrest both types.

Aircraft barriers are also designed for a normal runout of a certain number of feet. The energy-absorbing capacity of the barrier is computed at so many foot-pounds, based on the normal runout on concrete or asphalt overruns. Unstabilized or sod overruns will increase the energy capacity by approximately 30 percent, whereas steel planking overruns will reduce the energy capacity by approximately 20 percent. Barriers also are designed for a certain engaging speed in knots. The limit speed and weight based on the energy capacity and runout of the barrier should not be exceeded, but, if the energy capacity of the barrier is surpassed, the aircraft will merely runout farther than the normal number of feet. Of course, we sometimes go ahead and use the barrier even though we expect that the barrier capacity will be exceeded. The reason we do this is that the aircraft velocity will be reduced by the runout; thus, the possibility of pilot injury and aircraft damage decreases. All operators and maintenance personnel of aircraft arresting barriers should be familiar with the limitations of the barriers they have at their own installation.

Barrier Limitations. As we stated previously, aircraft barriers have certain capacities and, consequently, because of their capacities, certain limitations. You can find the capacities, as well as the limitations, in the applicable technical orders. A few limitations of barriers are discussed below.

- Some barriers are not designed for, or readily adapted to, propeller-driven aircraft, because the webbing may become entangled with the propeller blades. This would present considerable danger to people in the vicinity. Other barriers are not designed to arrest jet bombers and cargo aircraft.
- In some cases, the webbing may bind on the nose strut and cause minor swerving of the aircraft, or cut electrical wires that control nosewheel steering.

Several types of barriers are currently in use at various Air Force bases. Each type has a device to absorb the energy of aircraft arrestment. The simplest form of energy absorber is the chain type. A modified aircraft disc type brake is used in two USAF barrier models. These are classified as rotary friction type energy absorbers. Still another type uses a water turbine to absorb the energy of arrestment.

Some of these barrier models are permanently installed, while others are portable. The operating principles and construction characteristics will be explained in the paragraphs that follow.

Exercises (252):

1. The energy-absorbing capacity of the barrier is computed at so many _____ - _______ .

2. The energy-absorbing capacity computations are based upon what?

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3. How do steel planking overruns effect the energy capacity?

4. Where will you find the capacities and limitations of the various barriers?

5. How may a barrier affect the steering of an aircraft?

6. The simplest form of energy absorber is the ________ ________.

253. Tell how the various parts of the chain type arresting barrier work.

Chain Type Arresting Barrier. Probably the simplest aircraft arresting barrier is shown in figure 8-1. A barrier of this design is based on the same principle as the barriers used aboard aircraft carriers.

As you see, a nylon webbing assembly is stretched across the runway so that when an aircraft nosewheel hits it, the action triggers a steel cable to engage the main landing gear struts of the aircraft. The kinetic energy of the aircraft is absorbed by having the cable pull out two heavy anchor chains that are placed parallel to the runway. The drag force applied to the main landing gear struts (due to the dragging chains) reduces the speed and finally stops the aircraft. An additional pendant, stretched across the runway in advance of the webbing assembly, is supported by rubber support discs and is also connected to the anchor chains. This pendant is designed to engage the arresting hook of aircraft so equipped.

The barrier consists of two steel stanchions which support the webbing assembly spanning the runway, intermediate supports for the webbing assembly and arresting cable, two arresting chains, and air-operated cylinders for raising and lowering the main stanchions. The cylinders are actuated from a remotely controlled pneumatic system. The pneumatic system consists principally of a main control box containing the air compressor, air accumulators, battery power supply, and associated controls. It is automatic and supplies the necessary air to the auxiliary control box and main stanchion actuating cylinders. The main stanchions may be raised and lowered by a remote switch in the control tower. Operating this switch energizes the necessary controls in the main and auxiliary control

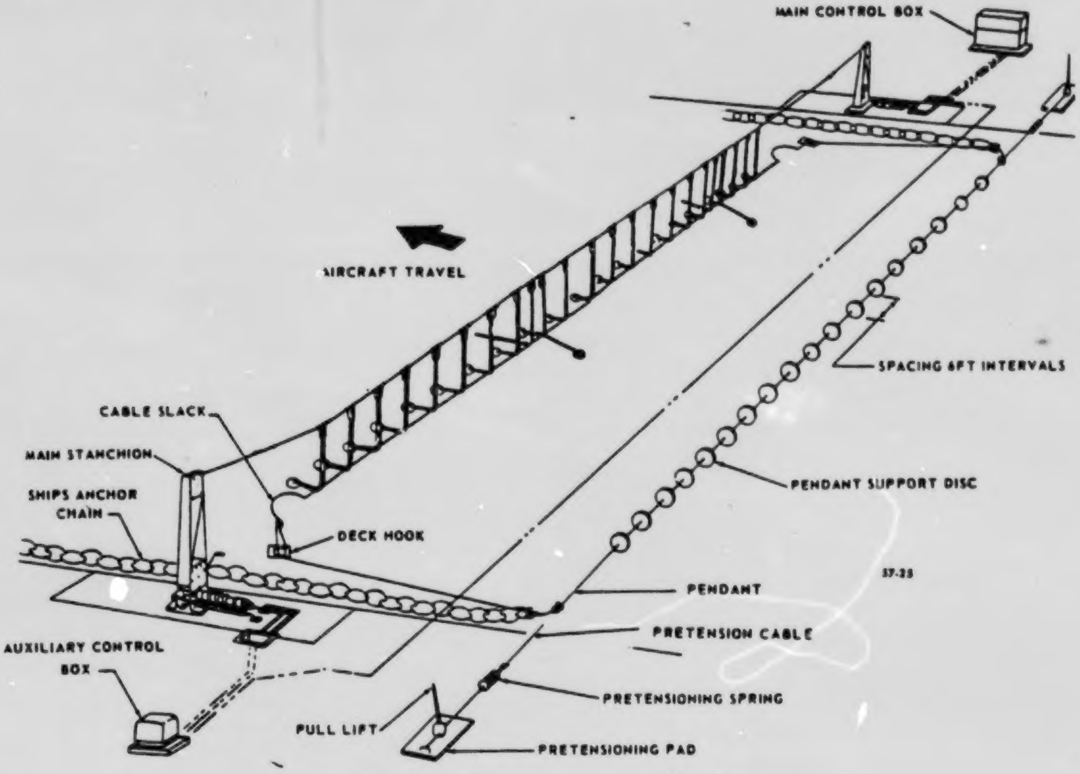

MAIN CONTROL BOX
AIRCRAFT TRAVEL
SPACING 6FT INTERVALS
CABLE SLACK
MAIN STANCHION
SHIPS ANCHOR CHAIN
PENDANT SUPPORT DISC
DECK HOOK
37-25
PENDANT
PRETENSION CABLE
AUXILIARY CONTROL BOX
PRETENSIONING SPRING
PULL LIFT
PRETENSIONING PAD

Figure 8-1. Chain type arresting barrier.

boxes to raise or lower the webbing assembly. A local control switch in the main control box will also operate the stanchions. The following paragraphs discuss some of the most important components of a chain type aircraft arresting barrier.

Webbing assembly. The webbing assembly, which is stretched across the runway to contact the aircraft, consists of two horizontal actuator straps to which a number of vertical lifter straps are attached (see fig. 8-2). Each lifter strap is rigged to the arresting cable by special fasteners. An extension of the vertical lifter strap is attached to an anchor plate imbedded in the runway.

Deck hooks. Deck hooks on each end of the webbing-assembly arresting cable provide a certain amount of slack for the cable. They lie flat on the overrun surface and are fastened with anchor bolts. Their purpose is to release the pendant at the proper instant during an arrestment.

Arresting chains. The energy absorber for this type of barrier consists of two ships-anchor chains. A chain is laid out on each edge of the runway in the direction of aircraft arrestment. It is arranged as a single chain for the first 90 feet – with the remaining chain (approximately 360 feet) being doubled. The system is designed for a 1000 foot runout, with an energy-absorbing capacity of 10 to 12 million foot-pounds. Additional chain may be used to gain a required absorber energy. You should refer to the specific technical order for details on the chain used.

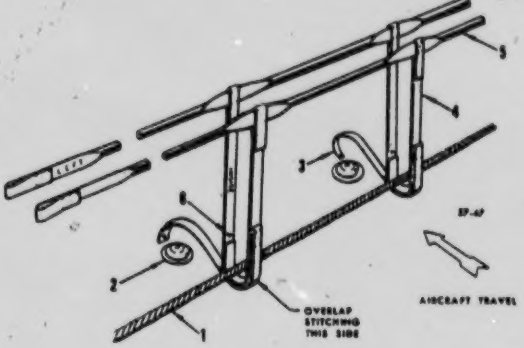
Main stanchions. These stanchions are mounted at the edge of the runway and serve as supports to the webbing assembly. Each stanchion incorporates a hand-operated winch for positioning and tensioning the webbing. The stanchions are also pivoted at their bases and equipped with pneumatic cylinders and springs. The cylinders raise the stanchions to the operating position, while the springs tend to dampen stanchion motion after engagement impact.

Intermediate stanchions. Intermediate stanchions are of tubular design and support the webbing assembly at the center of the runway. They are designed to disassemble upon impact. For this reason they must be replaced frequently.

Main control box. Most of the automatic controls and equipment for the barrier are in the main control box. Some of the units included are the air compressor, air accumulators, power units, storage batteries, valves, relays, circuit breakers, switches, and associated equipment.

Auxiliary control box. The auxiliary control box is located on the opposite side of the runway from the main control box. It contains only a few components: valves, one air accumulator, and units of similar nature.

Electrical systems. This barrier is normally supplied with ac power from the base. The ac power is required to charge the batteries. Power from the batteries is used to operate the air compressors. In the event of ac power failure, the batteries can operate the system for several hours. This, you can see, is an important advantage of a battery-powered system.



1. Arresting cable
2. Anchor plate
3. Grommet
4. Vertical lifter strap
5. Actuator strap
6. Lock type fastener

Figure 8-2. Portion of webbing assembly.

Compressed air system. This system includes two high-pressure air compressors, accumulators, valves, gauges, switches, relays, and related components. The system is entirely automatic and requires no attendance by the operator. The air compressor system components are located in the control boxes. In most cases the operation of the barrier requires low-pressure as well as high-pressure air.

Pendant assembly. To arrest hook-equipped-type aircraft, an additional pendant – connected to the chains and supported by rubber discs – is stretched across the runway (see fig. 8-1). The pendant cable is usually about 1 inch in diameter, and each end is attached to a pretensioning pad through pretensioning cables, springs, and a pull lift. The pull lift is operated manually and used to pretension the pendant cable, while the springs allow the pendant to yield as aircraft run over it.

Rotary Friction Type Barrier. This type of arresting barrier uses a modified multiple-disc type of aircraft brake as the energy-absorbing device. Two USAF models of the rotary friction type barrier are in use at AF bases. One model is permanently installed, while the other model may be either a temporary (expeditionary) or a permanent barrier. Since a large number of these barriers are in use, you are likely to encounter both types in your duty assignments.

Exercises (253):

1. How is the kinetic energy of the aircraft absorbed?

2. What supports the webbing assembly spanning the runway?

3. The remote switch for raising and lowering the main stanchions is located where?

4. What is the purpose of the deck hooks?

5. Approximately how many feet of anchor chain is used for 10 to 12 million foot-pounds of energy-absorption?

6. What are intermediate stanchions used for?

7. Power from the batteries is used for what purpose?

8. How is the pull lift that is used to pretension the pendant cable operated?

9. What purpose do the spring in the pendant assembly serve?

254. Give the basic structural features and capabilities of the permanent installation barrier.

Permanent Installation Barrier. The barrier in its "standard configuration" is shown in figure 8-3. This barrier is compatible with hook-equipped aircraft traveling in either direction. You can see the pendant extending across the runway and being supported by synthetic rubber discs. Each pendant end is connected to a purchase tape. The tape passes through a runway edge sheave, then by and around a series of deflector sheaves, and around the tape storage reel of the reel and shaft assembly. Notice that the tape connected to one end of the pendant must pass under the runway to the reel and shaft assembly. Looking at table 8-1, you see a listing of the leading particulars of this model barrier. Some of the significant ones will be discussed below.

a. Energy-absorbing capacity. The figure here tells you that the barrier can absorb 55,000,000 (55×10^6) foot-pounds of energy. This relates to operational factors such as aircraft weight – 40,000 pounds, engaging velocity – 190 knots, and aircraft runout – 950 feet.

b. Rewind system. Here you see that an electric motor is used to rewind the system. With a 950-foot run-out, you could rewind the tapes in 3½ minutes. Also, you see the voltage and frequency ratings of the motor.

c. Purchase tape. Notice that the type of material and ultimate strength are given. The ultimate strength of the tape is based on the energy-absorbing capacity of the barrier.

d. Runway pendant. The size and construction data of the pendant is given. Notice that it is supported at 6-foot intervals.

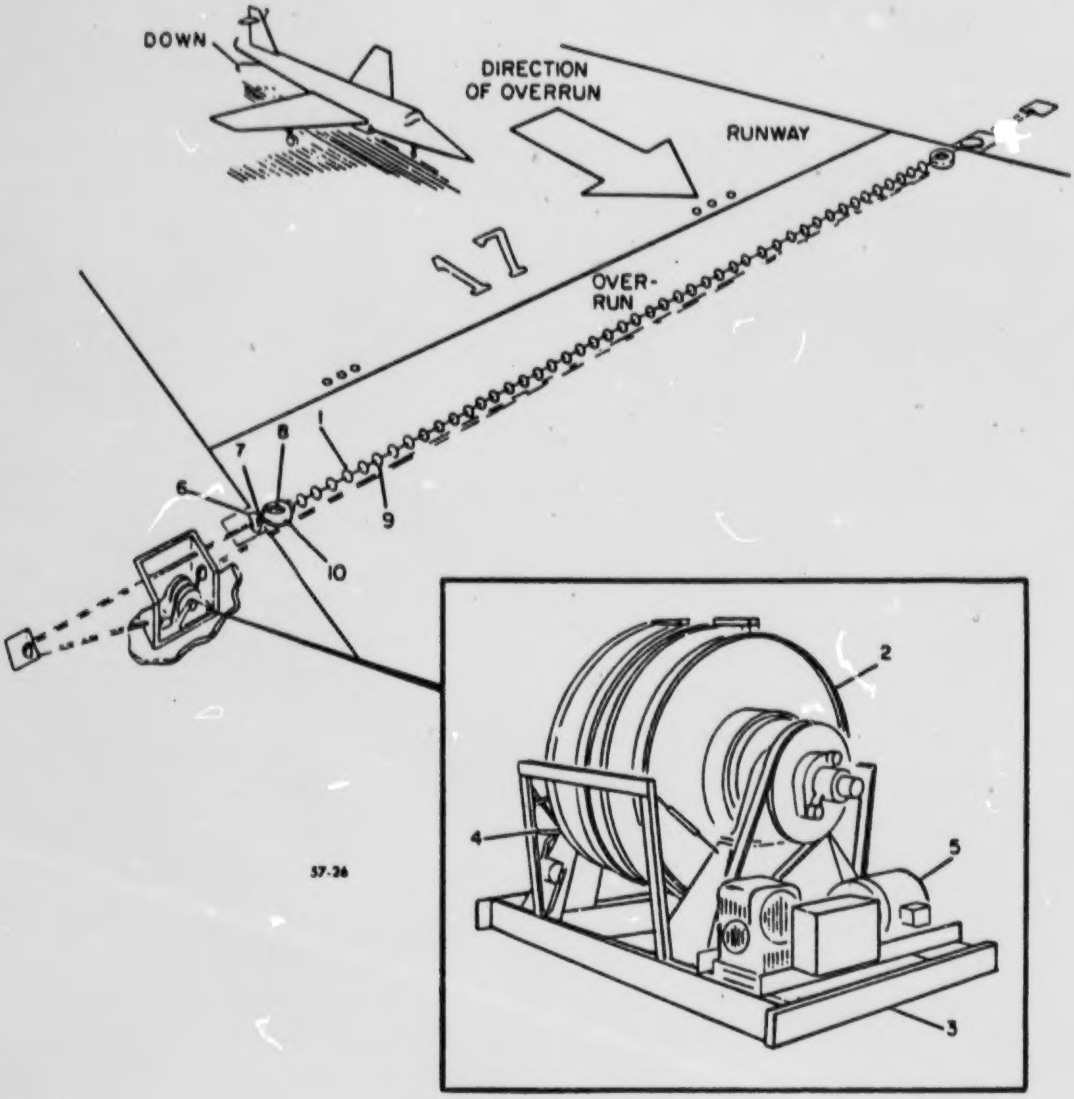
e. Other items, such as the barrier weight, size, etc., are given also. Study this table carefully to get a good mental picture of this model barrier. Once you know this information, you should be able to compare this barrier to the portable (expeditionary) model barrier to be discussed later.

Barrier operation. The tail hook on the airplane engages the runway pendant. As the airplane continues down the runway, the tapes are reeled out through the runway edge sheaves. Tape reel rotation is opposed by the rotary friction of disc type brakes. As stated previously, the system is designed to arrest a 40,000 pound aircraft with about 950 feet of runout. After the airplane is halted, the hook is disengaged from the pendant and an electric motor rewinds the tapes on the tape reels. The pendant is then pretensioned, returning the barrier to the battery position. The rewind operation takes about 3½ minutes.

To arrest aircraft not equipped with a hook, the webbing and pendant assembly of the chain type of barrier may be used. In figure 8-4, you can see this engaging system interconnected with the standard configuration pendant. A "J" hook is used to connect the two pendants. In operation, the airplane rolls over the disc-supported pendant, and then the nose gear contacts the webbing assembly. The lifter straps flip the pendant cable up so that it engages the main landing gear strut. As the airplane continues down the runway, a sequence of events occurs as follows: the "J" hook (5) engages the eye of the link assembly (4), which interconnects with the standard configuration pendant (1); the purchase tape is reeved off the storage reels through the runway edge sheaves; and then the airplane is halted by the friction brake, as explained previously.

In the following paragraphs, you will read in detail about some of the more important components. Included will be the reel and shaft assembly, purchase tapes, runway edge sheaves, pendant, and hydraulic system.

Reel and shaft assembly. The reel and shaft assembly, as pictured in figure 8-5, consists of two reels which store nylon purchase tape. These reels and a disc clutch are mounted on a common shaft. The clutch locks the two reels and a common shaft together, and thus causes them to function as a common unit. Disc brakes mounted to the ends of the shaft provide braking action when an aircraft is arrested. One brake is provided for each reel. Reel motion during arrestment drives the main hydraulic pump and cam gear box (shown in fig. 8-6). The



1. Runway pendant assembly
2. Reel and shaft assembly
3. Frame assembly
4. Hydraulic system
5. Retraction equipment
6. Runway edge sheave
7. Purchase tape assembly
8. Tape connector assembly
9. Pendant support disc
10. Tire casing

Figure 8-3. Rotary friction type arresting barrier.

pump produces the hydraulic pressure required to energize the brakes. The gear box drives a cam at reduced speed. The cam operates a valve which controls the hydraulic pressure to the brakes. The control of hydraulic pressure is such that the aircraft is decelerated so as to make a smooth stop.

The shaft assembly has a drive hub and sprocket on the rewind end, as shown in figure 8-7. During arrestment the shaft is disengaged from the drive hub and runs free of the sprocket. Following arrestment, the drive hub is engaged manually by means of the rewind pin (1) and hole arrangement. The sprocket is chain driven by an electric motor which is the power source for rewinding the

TABLE 8-1

LEADING PARTICULARS OF THE PERMANENTLY INSTALLED ROTARY FRICTION MODEL BARRIER

Item	Data
Gross Weight	6800 lb
Dimensions:	
Length	103 in.
Width	66 in.
Height	70 in.
Energy absorbing capacity	55×10^{6} ft lb
Aircraft weight (nominal)	40,000 lb
Aircraft runout (nominal)	950 ft
Aircraft weight/runout selection method	fixed cam
Ambient temperature operating range	-40° F to + 125° F
Maximum allowable engaging velocity	190 knots
Rewind system type	electric
Rewind motor power requirement	440 v, 3 ph. 60 cy or 220 v, 3 ph, 60 cy or 208 v, 3 ph, 60 cy or 380 v, 3 ph, 50 cy
Rewind time (950 ft runout)	3-1/2 min
Number of men required to rewind	one
Purchase tape material	nylon
Purchase tape ultimate strength	65,000 lb
Accessory services required	high-pressure air
Runway pendant construction	1" 18 x 7 wire rope
Runway pendant length	to suit width of runway
Pendant support disks	at 6 ft. intervals along pendant cable
Engagement direction	bidirectional

57.91

purchase tapes on the reels. The rewind pin is designed to shear if it is left engaged when an arrestment is made.

Purchase tape is a woven nylon belt. Basically, this belt is a long, flat bag that contains bundles of nylon fibers that run lengthwise, as you see in figure 8-8. The fibers bear the primary load of the belt. The tape edges are reinforced to protect the fibers from wear. The tape is approximately 8 inches wide, .35 inch thick, and is of sufficient length to allow normal runout. It has a breaking strength of approximately 65,000 pounds. The tape attaches to the pendant by a connector with a mechanical clamping arrangement. In this arrangement, the tension on the tape provides the clamping force.

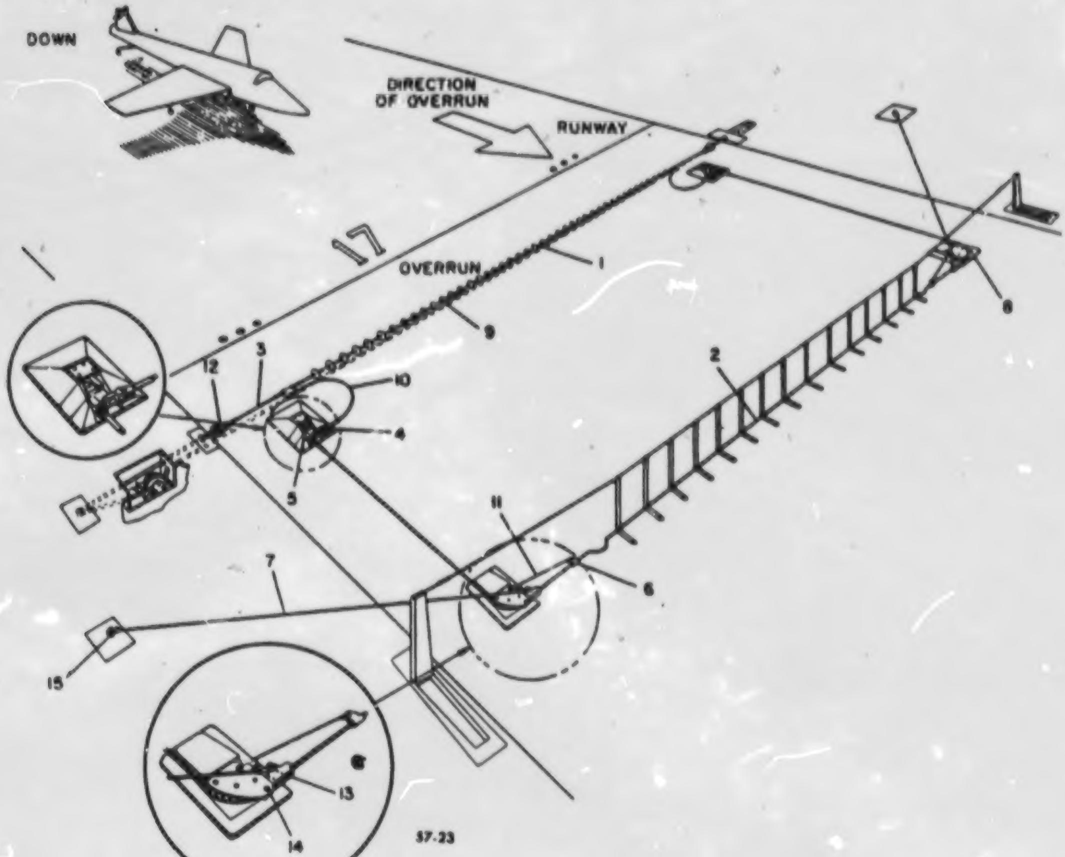
A tape connector tire casing, as you see in figure 8-9, is used to eliminate tape twist caused by the rolling action of the pendant support discs. One must be installed on the tape pendant connector on each side of the runway. The tires also minimize wear of the tape connectors and will not hamper barrier performance. You also see the runway edge sheave from which the tape is pulled out during an arrestment.

Pendant. The pendant used with this type of aircraft arresting barrier is similar to those mentioned previously in this chapter.

Hydraulic system. The hydraulic system shown in figure 8-10 operates the two brakes and the clutch. You need to know how the system maintains a battery (ready) condition as well as how it operates during arrestment.

In the battery condition, a certain amount of system pressure is required to energize the brakes and clutch. The brakes prevent the reels from turning when the pendant is pretensioned. At the left of figure 8-10, you can see the brake static accumulator. It is charged to the specified pressure through the air charging valve. This pressure acts through the static selector valve and piloted shuttled valve to both brakes. The shuttle valve blocks the passage to the reel-driven pump. At the right of the schematic (fig. 8-10) is the clutch accumulator. It is also charged to a specified pressure which is applied to the clutch. Again, a shuttle valve blocks off the main hydraulic system, which is connected to the reel-driven pump.

Hydraulic system operation. During an arrestment, the following sequence of events happens. The airplane engages the runway pendant and starts reeling out the tape. The tape reels rotate at a speed related to that of the airplane. The reel-driven pump develops a pressure that acts on the two shuttle valves. These valves shift to allow



1. Runway pendant assembly, BAK-9
2. Runway pendant assembly, MA-1A
3. Intermediate runway pendant assembly, BAK-9
4. Eye link
5. "J" hook assembly
6. Cable clamp and sheave device
7. Nylon rope
8. Rub block
9. Pendant support disc
10. Interconnect pendant assembly
11.

Shear device pendant

12. Tape connector assembly
13. Clamp assembly
14. Shear pin
15. Anchor bolt

Figure 8-4. Standard pendant with webbing interconnect.

pump pressure to be applied to the brakes and clutch. The amount of pressure depends on the speed of the pump and the position of the cam. The cam regulates the cam control valve. To control pressure, this valve bypasses fluid back to the reservoir. The pressure gage indicates the maximum pressure developed during arrestment. A relief valve, above the cam control valve, protects the system from overpressure.

After each arrestment, the barrier must be returned to the battery position. To do this, you must rewind the tapes on the storage reels and pretension the pendant. To rewind the tapes, you must engage the rewind pin (fig. 8-7) manually by positioning the sprocket wheel until a hole aligns with the pin.

CAUTION: *Never use the rewind motor to align the pin and holes.* Press the rewind "reverse" button. This energizes the special high-torque motor which energizes the tape reel through a fluid coupling, speed reducer, sprocket, and chain. Release the rewind "reverse" button when the pendant is 10 to 20 feet from the battery position.

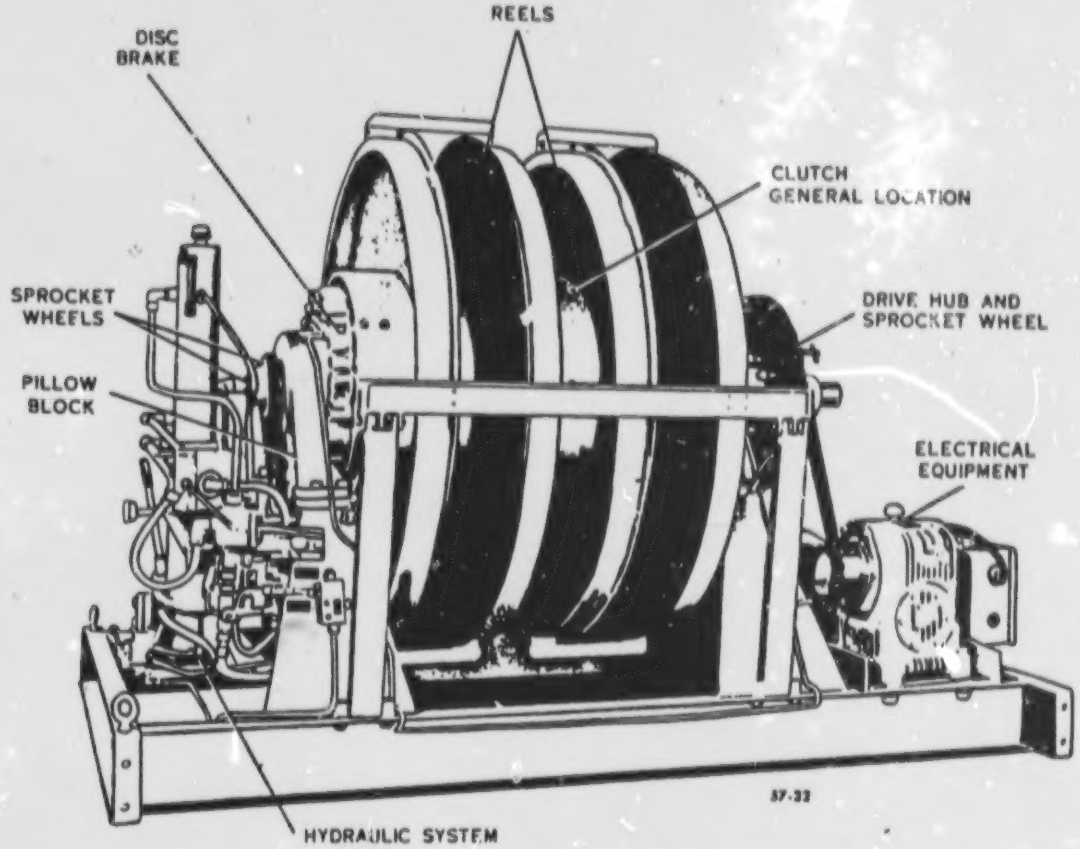


Figure 8-5. Reel and shaft assembly.

After allowing the pendant and tape connectors to come to rest, press the rewind "start" button to finish rewinding the tape. With the tapes fully wound and the pendant taut, depress the button on the shuttle valve (fig. 8-7) momentarily. Release the reverse button to deenergize the rewind motor.

NOTE: *While the shuttle valve is depressed momentarily, the electric rewind motor, acting through the fluid coupling, will apply the necessary torque-to pretension the pendant cable to the specified value.* Pull out the rewind pin, turn the pin, and release it so the pin handle rests in the shallow groove of the rewind cap.

Some fluid is lost from the brake static accumulator during arrestment. If no fluid is visible at the fluid level sight glass (fig. 8-6), operate the manual transfer pump until the fluid is replenished. Check the gage for the proper accumulator air pressure, and service it with compressed air if required. Note the readings on the hydraulic pressure gage (fig 8-10) and the tachometer (located on the hydraulic system side of reel and shaft assembly). You can correlate these readings to aircraft engaging speed and weight by using TO charts. Reset the pressure gage and tachometer indicator to zero.

A zero index mark is provided on the cam that operates the cam control valve. This zero index mark on the cam must be set on the cam follower.

With the tape rewound, the runway pendant pretensioned properly, the accumulators charged to the correct pressures, proper fluid level in the brake accumulator sight glass, and the zero cam index on the follower, the barrier is restored to the *battery position.*

Exercises (254):

1. The permanent installation barrier in its standard configuration is compatible with hook-equipped aircraft traveling in what direction?

2. How many foot-pounds of energy can the barrier absorb?

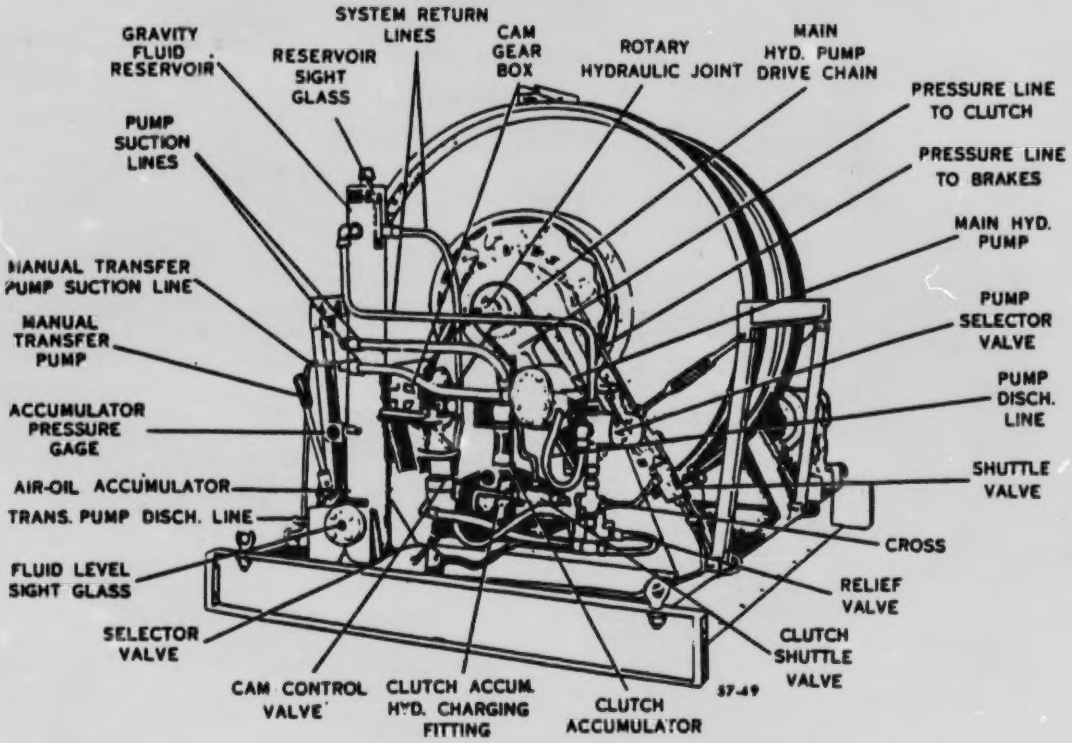

SYSTEM RETURN LINES
GRAVITY FLUID RESERVOIR
RESERVOIR SIGHT GLASS
CAM GEAR BOX
ROTARY HYDRAULIC JOINT
MAIN HYD. PUMP DRIVE CHAIN
PRESSURE LINE TO CLUTCH
PRESSURE LINE TO BRAKES
MAIN HYD. PUMP
PUMP SUCTION LINES
MANUAL TRANSFER PUMP SUCTION LINE
MANUAL TRANSFER PUMP
PUMP SELECTOR VALVE
PUMP DISCH. LINE
ACCUMULATOR PRESSURE GAGE
AIR-OIL ACCUMULATOR
SHUTTLE VALVE
TRANS. PUMP DISCH. LINE
CROSS
FLUID LEVEL SIGHT GLASS
RELIEF VALVE
SELECTOR VALVE
CLUTCH SHUTTLE VALVE
CAM CONTROL VALVE
CLUTCH ACCUM. HYD. CHARGING FITTING
CLUTCH ACCUMULATOR
37-49

Figure 8-6. Hydraulic system.

3. The system is designed to arrest a 40,000 pound aircraft with a runout of about how many feet?

4. About how long does it take for a rewind operation?

5. How does the pendant cable engage the main landing gear strut on aircraft not equipped with a hook?

6. Aircraft not equipped with a hook are halted by what means?

7. How do the brakes get the hydraulic pressure required to energize them?

8. What is the breaking strength of the purchase tape?

9. What is used to eliminate tape twist caused by the rolling action of the pendant support disks?

10. Air pressure passage to the reel-driven pump is prevented by the ____ ____.

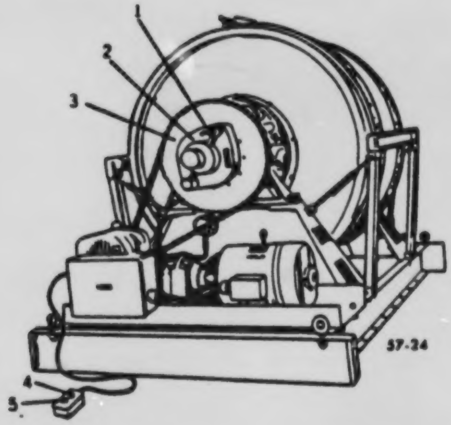
11. How is the barrier returned to the battery position?

12. How is the rewind pin positioned in the sprocket wheel?

13. Where is the zero cam index set when the barrier is in the battery position?

255. Give the basic structural features and capabilities of the portable (expeditionary) barrier.

Portable (Expeditionary) Barrier. The rotary friction type barrier, using the modified aircraft disc type brake, has been developed for use in remote or forward areas. It is designed primarily for installation as a portable "expeditionary" barrier, as shown in figures 8-11 and 8-12. Figure 8-11 is the



1. Rewind pin
2. Hub
3. Spocket
4. "Reverse" button
5. "Start" button

Figure 8-7. Rewind system.

standard installation, while figure 8-12 shows the barrier with the fairlead beam bolted to the arresting engine. Figures 8-13 and 8-14 show the barrier installed in its semipermanent and permanent configurations respectively. In the semipermanent installation, notice that concrete bases are provided for the arresting engines and deck sheave assemblies. In the permanent installation, the arresting engines are installed in concrete pits. Table 8-2 lists the leading particulars of this model barrier. The following discussion explains some of these particulars and compares some of the capabilities of this barrier to those of the permanently installed rotary friction model barrier.

a. Energy-absorbing capacity. This is specified as 65,000,000 (65 × 10^6) foot-pounds. Again, this relates to the aircraft weight, maximum engaging velocity, and runout. These are the same as the previous barrier; however, its energy-absorbing capacity is 10,000,000 foot-pounds more than the previous barrier. The reason for this will be discussed later.

b. Rewind system. Because this is an expeditionary type barrier, it is designed to operate in remote areas. Such areas may not have electrical power; therefore, a gasoline engine is used to rewind the tapes of this barrier. Notice that the rewind time is 3 minutes.

c. Purchase tape. Note that the ultimate tape strength is 105,000 pounds (40,000 pounds more than the previous model). This is a factor contributing to the higher energy-absorbing capacity mentioned above.

d. Runway pendant. You will notice that this pendant appears to be the same as the previous one.

e. Arresting engine. Although this information is too detailed to list on this type chart, it should be considered here. Each arresting engine (whether it is 2-cylinder or 4-cylinder) has two comparable disc type brakes. This gives the barrier four brakes as compared to the two energy-absorbing brakes of the previous barrier.

The standard expeditionary barrier. In figure 8-11 you can see the pendant (1) extending across the runway and being supported by neoprene rubber discs (2). The pendant aids (3) are connected to the purchase tapes (4) on either side of the runway. Fairlead beams (5) contain the runway edge sheaves and deflector sheaves to guide and pay out tape during an arrestment. Fairlead tubing, through which the tapes pass, extends from the fairlead beams to the arresting engine. Two arresting engines are provided, one on each side of the runway.

The barrier is air transportable and can be installed in its expeditionary configuration in about 8 hours. It can absorb 65,000,000 pounds of energy,

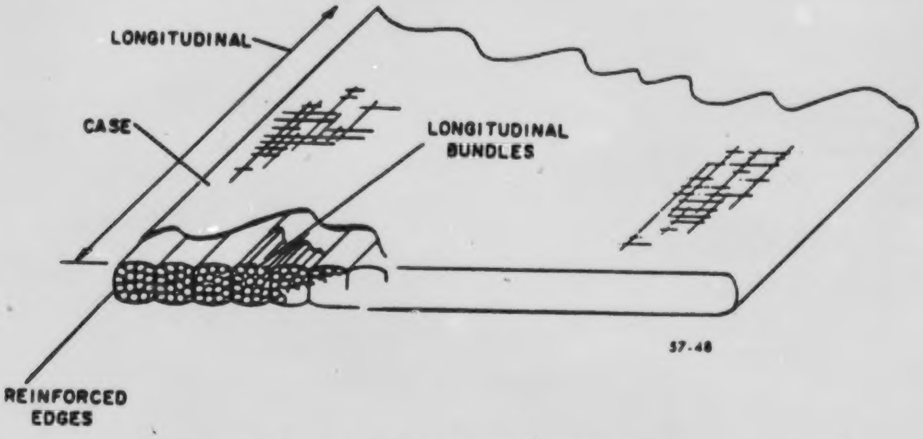


Figure 8-8. Purchase tape construction.

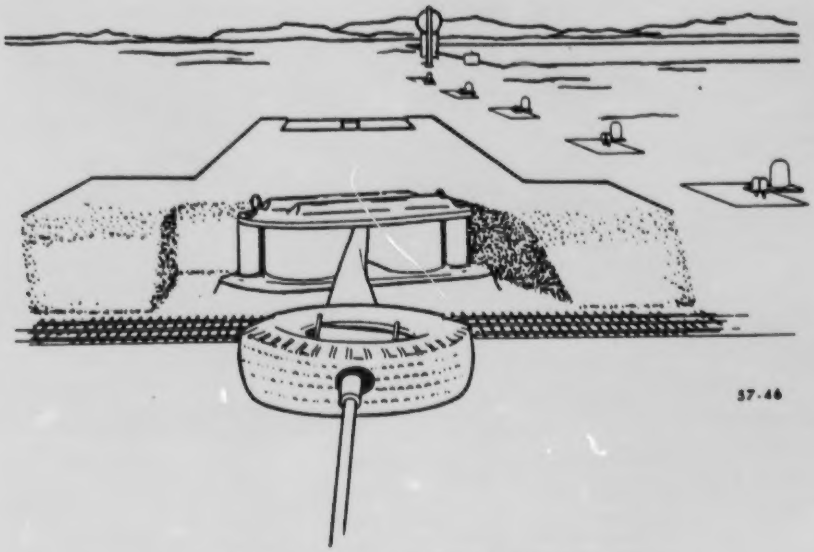


Figure 8-9. Tape connector tire casing.

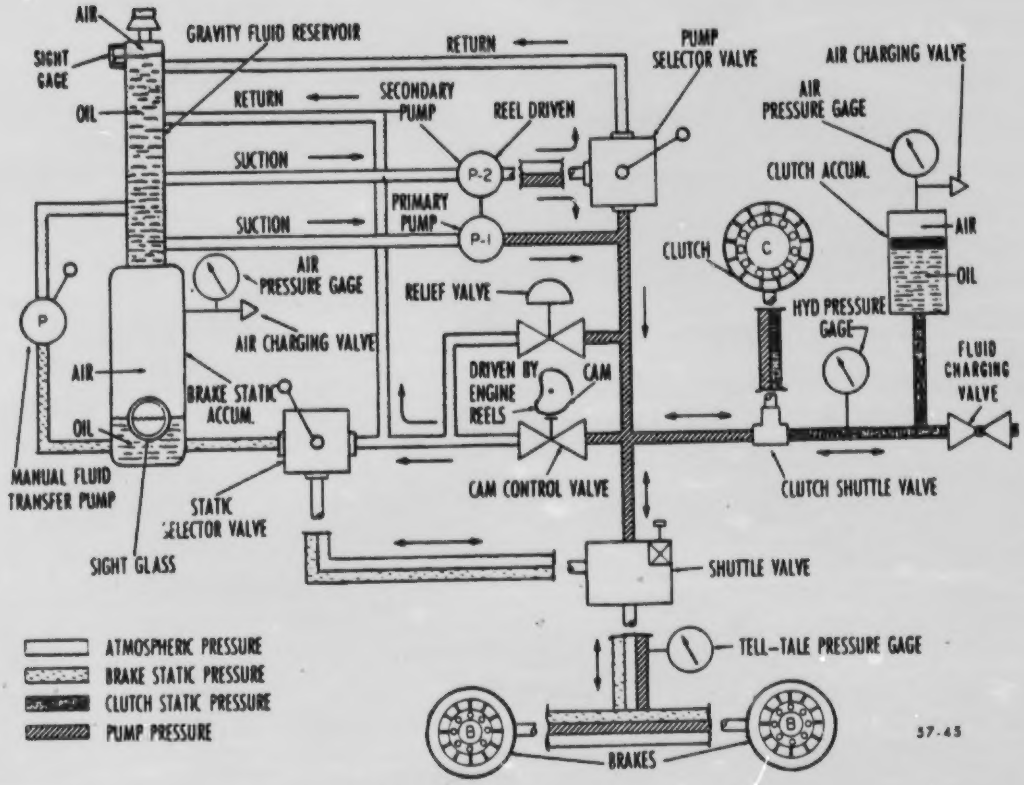
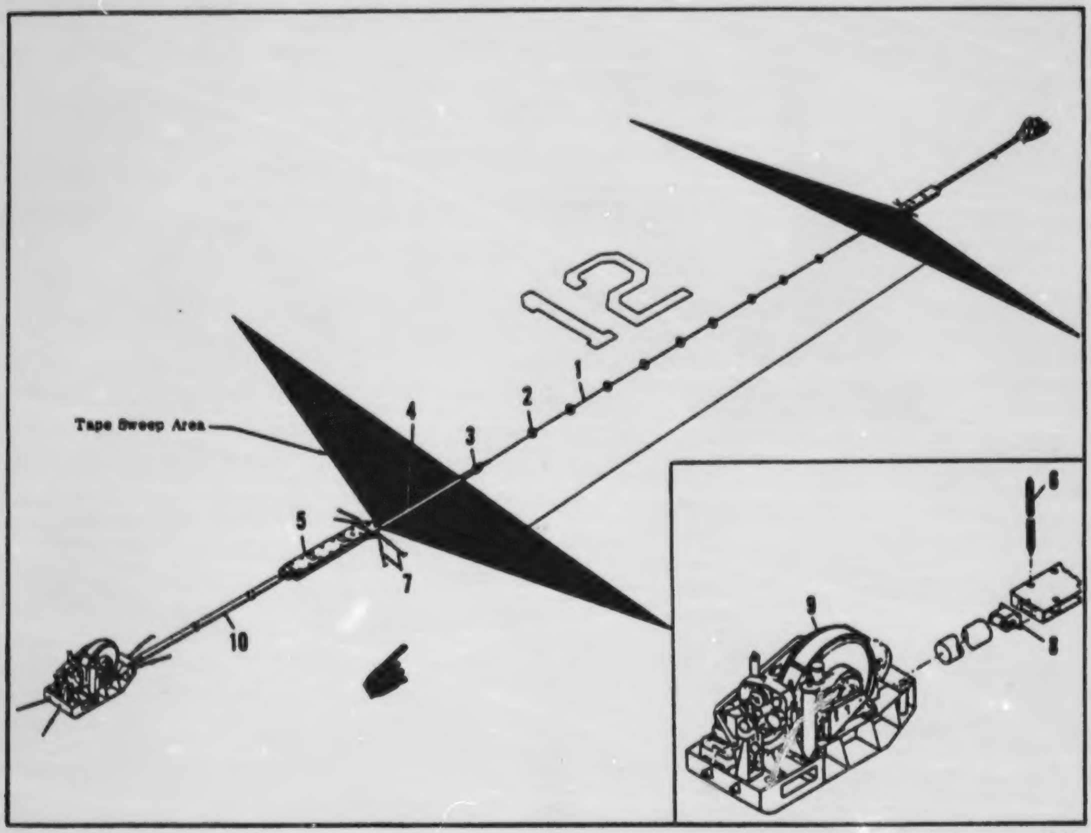

AIR
SIGHT GAGE
GRAVITY FLUID RESERVOIR
RETURN
PUMP SELECTOR VALVE
AIR CHARGING VALVE
OIL
RETURN
SECONDARY PUMP
REEL DRIVEN
AIR PRESSURE GAGE
SUCTION
P-2
CLUTCH ACCUM.
PRIMARY PUMP
SUCTION
P-1
AIR
CLUTCH
C
OIL
AIR PRESSURE GAGE
RELIEF VALVE
HYD PRESSURE GAGE
P
AIR CHARGING VALVE
FLUID CHARGING VALVE
AIR
DRIVEN BY ENGINE REELS
CAM
BRAKE STATIC ACCUM.
OIL
MANUAL FLUID TRANSFER PUMP
STATIC SELECTOR VALVE
CAM CONTROL VALVE
CLUTCH SHUTTLE VALVE
SIGHT GLASS
SHUTTLE VALVE
TELL-TALE PRESSURE GAGE
ATMOSPHERIC PRESSURE
BRAKE STATIC PRESSURE
CLUTCH STATIC PRESSURE
PUMP PRESSURE
B
B
BRAKES
37-45

Figure 8-10. Hydraulic system schematic.



1. Pendant assembly
2. Pendant support discs
3. Tape connector
4. Tape
5. Fairlead beam
6. Anchor stake
7. Earth anchors
8. Fairlead lead-on sheave
9. Arresting engine
10. Fairlead tubing

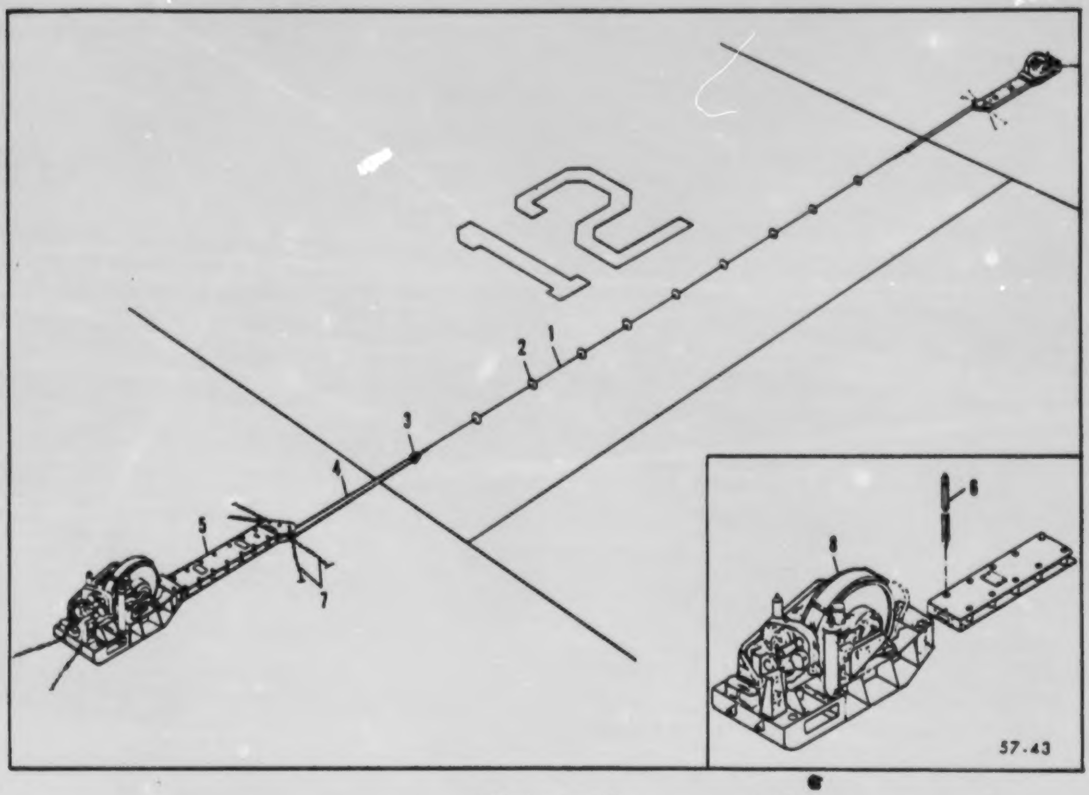
Figure 8-11. Standard (expedionary) barrier installation.

with engagements being made from either direction. The nominal tape runout during arrestment is 950 feet. You should note that an arresting engine (9) is positioned on each side of the runway. The arresting engines and fairlead beams are secured by use of special stakes (6) and earth anchors (7).

The earth anchor. The anchor, as seen in figure 8-15, is made in the form of a 2-inch, 4 ½ feet long, steel anchor tube. For use in loose soil, threaded steel segments can be screwed into the main section so that the anchor can be driven to the proper depth. It is driven into the soil with a pneumatic hammer and a special driving head. An explosive charge is then placed in the base of the tube and detonated. The explosion spreads the lower end of the tube and forms a cavity in the earth. Grouting (similar to cement) is mixed and poured through the tube to fill the cavity. The assembled adapter and tie-down adapters are shown in figure 8-16. These are used to connect the earth anchor to the equipment being secured.

The arresting engines. The arresting engines, as shown in figure 8-17, are similar to the one discussed previously. The main differences are: the reel and shaft assembly consists of one tape reel and two rotary friction brakes, a gasoline engine on each unit rewinds the tape; and each engine has an instrument panel, a battery, and a fuel tank.

To arrest non-hook-equipped aircraft, the barrier runway pendant may be interconnected with the webbing type of engaging system as explained



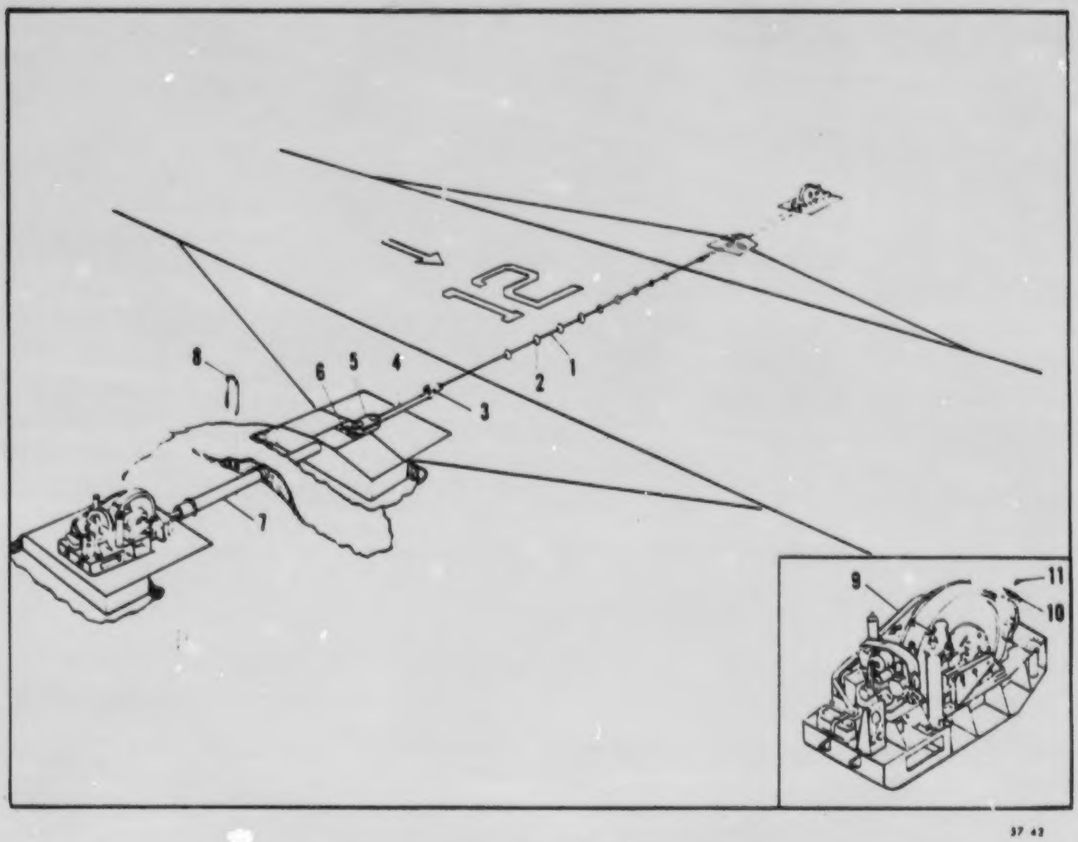
1. Pendant assembly
2. Pendant support discs
3. Tape connector
4. Tape
5. Fairlead beam
6. Anchor beam
7. Earth anchors
8. Arresting engine

Figure 8-12. Bolted-up (expeditionary) barrier installation.

previously. This interconnect arrangement is shown in the lower right area of figure 8-18. In the upper part of the figure, you see a different engaging system. It also can be used to engage aircraft not equipped with a tail hook. Since, perhaps, this device is new to you, it will be discussed in detail. In figure 8-18, you can see the runway pendant lying in a trough across the runway. Below the pendant are quick-opening, high-pressure air valves. These valves can be opened very quickly to propel the pendant upward at a precise time. To the left of the pendant cable trough are two rows of switch mats. A computer is used in conjunction with the switches to control the opening of the high-pressure air valves in the cable trough. The system is designed for off center engagements to within 30 feet of the runway edge.

Refer to figure 8-19 while you read the following explanation of the system operation. The information on this figure is in the form of events keyed to specific time intervals. The airplane nosewheel is approaching the first row of switch matting (S1). The airplane is traveling down a certain section of the runway relative to the centerline at a specific velocity or speed. System operation is based on these two factors, location and speed. The nosewheel contacts switch matting (S1). The location of the airplane is now identified. The air valves under the pendant that are directly ahead of the airplane are selected. The airplane nose and main landing gear wheels progress through times t2 through t7, where the engagement is made. During this sequence of events, the system computes the airplane speed and opens the air valves located in front of the main landing gear wheels. The valves open at the proper instant to engage the airplane.

When the airplane tail hook or main landing gear strut contacts the pendant, tape is reeved out from the tape reels. The brakes, two for each reel, decelerate and stop the airplane in essentially the same manner as explained previously. The two energy absorbers function independently of each



1. Pendant assembly
2. Pendant support discs
3. Tape connector
4. Tape
5. Deck sheave assembly
6. Tape brush assembly
7. Fairlead tubes and couplings
8. Fairlead tube anchor
9. Arresting engine
10. Tape clamp
11. Screw

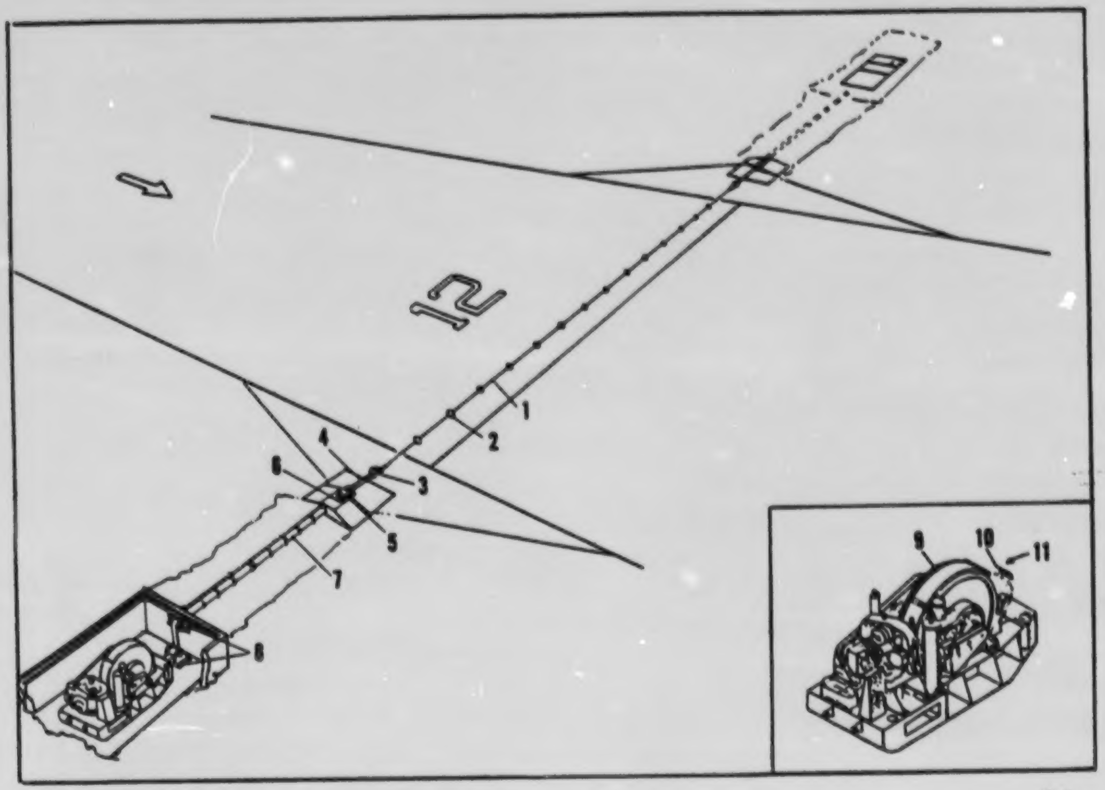
Figure 8-13. Semipermanent barrier installation.

other. If the braking action on one reel is greater than on the other reel, the payout of the tape will be unequal and the airplane will "yaw," or move toward one side of the runway.

The tapes are rewound by the gasoline engines. Each engine drives its respective tape reel through a fluid coupling, gear reducer, and rewind clutch. Then it pretensions the pendant through the fluid coupling and rewind clutch.

The braking force of each reel and shaft assembly must be equal, or "synchronized." The system is synchronized initially when it is installed. Thereafter, it is synchronized at time intervals specified by the TO (usually 6 months), or when you replace a unit that affects synchronization, or when there is unequal tape payout during an arrestment. The method is to obtain a particular brake pressure at a reference location on the cam while the main pump is driven at a given rpm. The rewind engine is used to drive the hydraulic pump. The procedure for connecting the engine to the pump varies with the type of engine being used. The typical synchronizing procedure is: With the reduction gear box drive chain removed, set the cam manually at 60°, set the engine throttle to drive the pump at 780 rpm, and adjust hydraulic pressure to 800 psig. On early systems, a turnbuckle barrel is rotated to make this adjustment. A needle valve is provided on later systems to make the adjustment.

This concludes the explanation of the rotary friction type arresting barrier. The next type we will



1. Pendant assembly
2. Pendant support discs
3. Tape connector
4. Tape
5. Deck sheave assembly
6. Tape brush assembly
7. Fairlead tubes and couplings
8. Deflector sheave assembly
9. Arresting engine
10. Tape clamp
11. Screw

Figure 8-14. Permanent barrier installation.

discuss is relatively new. It operates on the water turbine principle.

Exercises (255):

1. How could you determine the aircraft engaging speed following an arrestment by a portable (expeditionary) rotary friction type barrier?

2. Why does the expeditionary rotary friction barrier have more energy-absorbing capacity than the permanently installed rotary friction barrier?

3. Give four significant differences between the portable (expeditionary) rotary friction model barrier and the permanently installed rotary friction model barrier.

4. Relative to the air-lifted pendant type aircraft engaging device, what is the purpose of the following component parts?
   a. Switch matting?

   b. Computer?

   c. Quick-opening high-pressure air valves?

5. Why and when is it necessary to synchronize the expeditionary rotary friction barrier?

TABLE 8-2

LEADING PARTICULARS OF THE PORTABLE (EXPEDITIONARY) ROTARY FRICTION MODEL BARRIER

Item	Data
Gross Weight	18,500 lbs (complete arresting barrier)
Dimensions:	
Length	125 inches
Width	52 inches
Height	61 inches
Energy absorbing capacity	65×10^6 ft. lb.
Aircraft weight (nominal)	40,000 lbs.
Aircraft runout (nominal)	950 ft.
Aircraft weight/runout selection method	Fixed cam
Ambient temperature operating range	-40° F to + 125° F
Maximum allowable engaging velocity	190 knots
Rewind system type	Gasoline engine
Packette engine	Aviation grade fuel--MIL-G-5572
Wisconsin engine	Fuel--MIL-G-3056 or MIL-G-5572
Lubricant	MIL-L-2104 grade 30
Hydraulic fluid	MIL-H-5606
Capacity	9 gal. (both sides included)
Coolant brakes	Water
Capacity	110 gal. (total both sides) required only for 6 to 12 arrestment per hour cycle
Rewind time (950 ft. runout)	3 min. max.
Purchase tape material	nylon
Purchase tape ultimate strength	105,000 lb. min. 8 1/2 in. wide and 0.225 in. thick
Runway pendant construction	1 inch dia. 18 x 7 non-spin wire rope
Runway pendant length	145 feet nominal or to suit runway width
Engagement direction	Bi-directional

57.90

6. Name the three steps in synchronizing this barrier.

256. Give the basic operating features of the turbine type arresting barrier.

Turbine Type Arresting Barrier. The turbine aircraft barrier can be used for either rapid cycle aircraft recovery, emergency recovery, or overrun operations of hook-equipped aircraft. The arresting system can be retracted within several minutes. Some of these barriers can be transported by air and installed for operation in 10 hours. You see a turbine type arresting barrier in figure 8-20.

A turbine aircraft barrier is a sensitive, hydraulic type of energy absorber. Two energy absorbers are operated by two operator consoles installed on opposite sides of the runway. The absorbers are interconnected by nylon purchase tapes and a runway pendant. As in other systems, the aircraft arresting hook engages the pendant stretched across the runway. The energy of the aircraft is absorbed in the liquid turbine during tape payout.

Turbine assembly. The turbine assembly, which is shown in figure 8-21, consists of a vaned rotor between two vaned stators in a housing filled with a water/glycol mixture. The turbulence caused by the rotor and stator operation converts the landing aircraft's kinetic energy into heat. A cooling system dissipates this heat during rapid cycle operations. After the aircraft has been safely brought to a stop and the tail hook disengaged, the retraction system returns the pendant and nylon tapes to the battery position.

Operator's console. All absorber components (except the runway components and the 500-gallon cooling tanks) are mounted on steel bases. These bases have stake holes and earth anchor attachments for securing the bases to the ground. Each absorber usually has an operator's console for all controls and instruments to operate the individual unit.

Storage reels. The storage reel of each absorber unit consists of a reel mounted on a shaft common with the rotor of the turbine. During arrestment, the storage reel is turned as the nylon purchase tape is pulled out by the aircraft. The rotation is transmitted to the turbine assembly by the reel-turbine shaft.

During a tape retraction operation, a retract sprocket and engaging assembly mounted on top of the storage reel assembly is used to drive the reel in reverse. Also mounted on top of the reel is a capstan used to retrieve the tapes manually in case of rewind engine failure.

Coolant system. The cooling system that is used with a turbine barrier system (see fig. 8-22) can hold

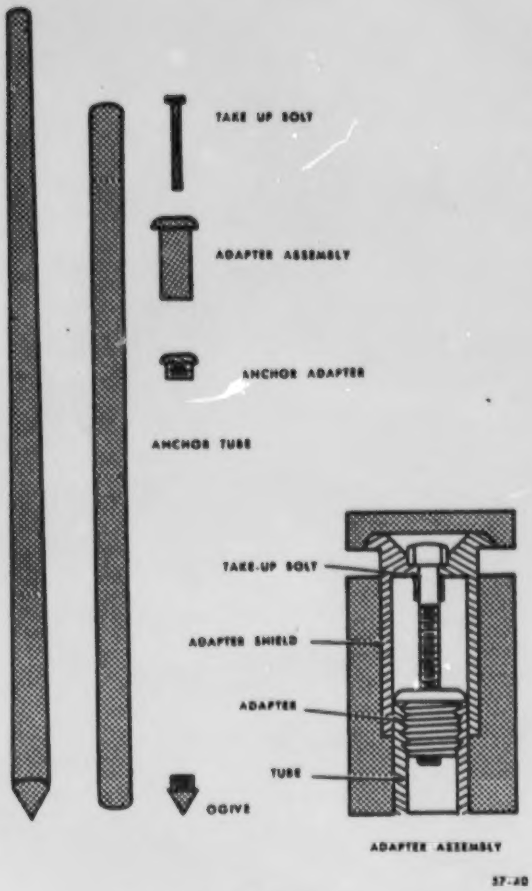


Figure 8-15. Earth anchor assembly.

about 500 gallons of 40 percent water and 60 percent glycol mixture for each absorber. The system includes a reservoir, temperature sensor, relief valve, rewind engine, circulating pump, and associated parts. There are three reasons for adding glycol to the water in the system: (1) the solution can be used in most ambient temperatures; (2) the glycol lubricates the turbine bearings; and (3) the more viscous solution increases the energy capacity of the barrier somewhat. As the turbine absorbs the kinetic energy transmitted through the tapes, heat is produced in the liquid. The heated liquid is circulated through the reservoir, where the heat is dissipated from the reservoir surfaces into the atmosphere.

Lead-off sheave assembly. This assembly is mounted on the base to guide the purchase tape from the tape storage reel to the runway edge sheave. A tape cleaning brush is usually mounted on the lead-off sheave assembly to remove stones, cinders, and other runway debris as the purchase tape rewinds.

Rewind system. A retracting unit rewinds the purchase tapes on the storage reels and pretensions the pendant in the battery position after arrestment. The unit's power source on this type of barrier may be a gasoline or a diesel engine, and in some cases an electric motor.

All instruments and controls for the rewind engine, or motor, are on the operator's console. If the rewind power unit fails to operate, the tapes may be retracted manually, using the capstan located on top of the storage reel. A transmission containing a torque converter and a clutch is the engaging mechanism for the power takeoff from the rewind power unit.

A retract sprocket and engaging mechanism connect the retract sprocket to the tape storage reel to rewind the tapes. The mechanism is engaged before and during retraction and remains engaged while the system is in the battery position. A backstop clutch prevents pendant tension from being released through the power train when the rewind engine is disconnected from the transmission and clutch. When an aircraft engages the pendant, the engaging force overcomes the holding pressure of the engaging mechanism; therefore, the storage reel is released to drive the turbine assembly for the arrestment cycle.

Tight-wrap roller assembly. A tight-wrap roller arm applies pressure to the purchase tape as it is being wound on the tape storage reel. After the pendant has been pretensioned, the operator swings tight-wrap roller arms away from the reels, and the barrier is now in the battery position.

Runway edge sheaves. These sheaves (see fig. 8-23) guide the purchase tapes to and from the storage reels. They allow an arresting force in either direction of runway travel. A runway sheave assembly is usually mounted on a separate steel base and installed at the edge of each side of the runway.

In addition to the components mentioned so far, the turbine absorber barrier includes a pendant, cable, and nylon purchase tapes. These units are similar to those already mentioned in this chapter.

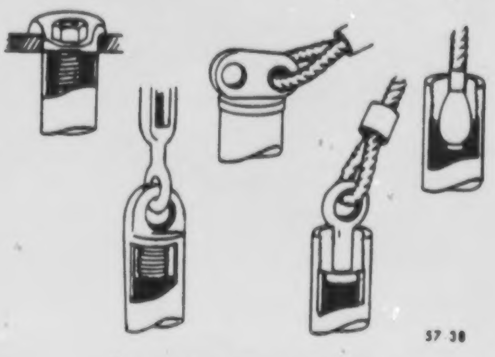
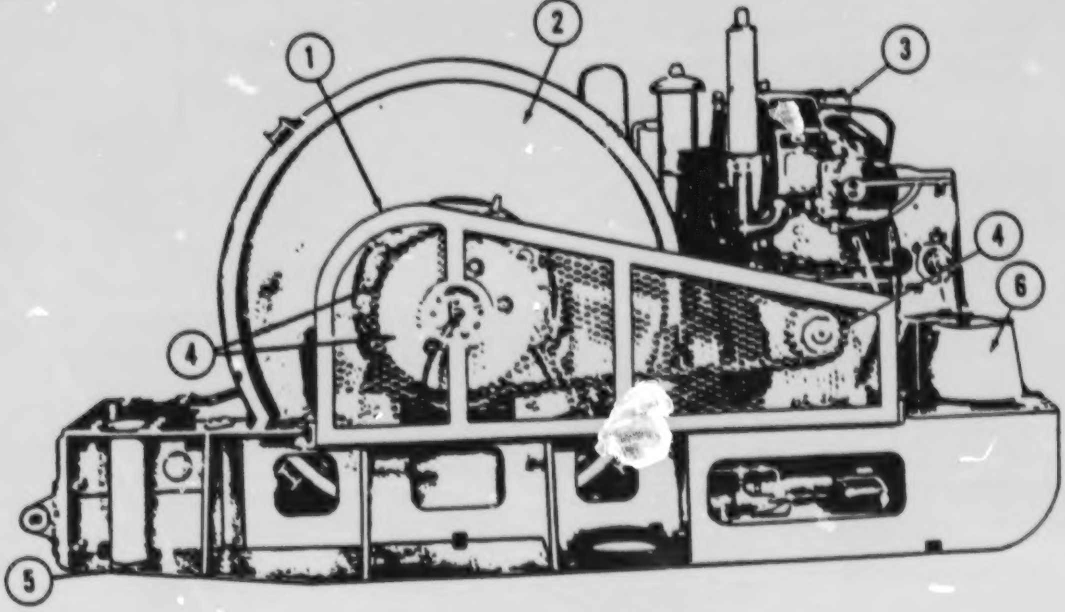
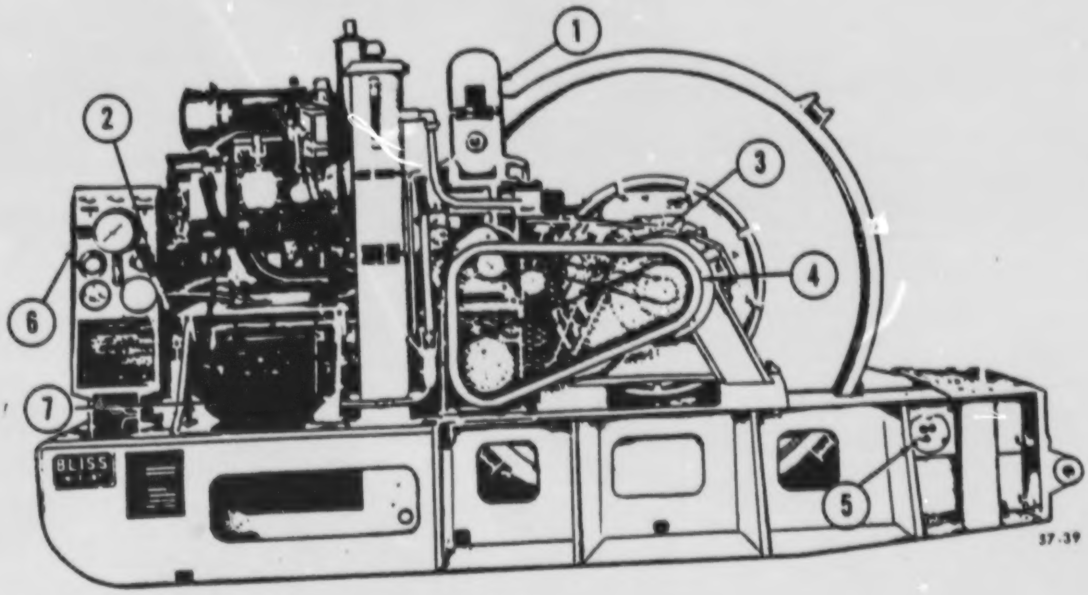


Figure 8-16. Tie-down adapters.



A. REWIND SIDE



B. CONTROL SIDE

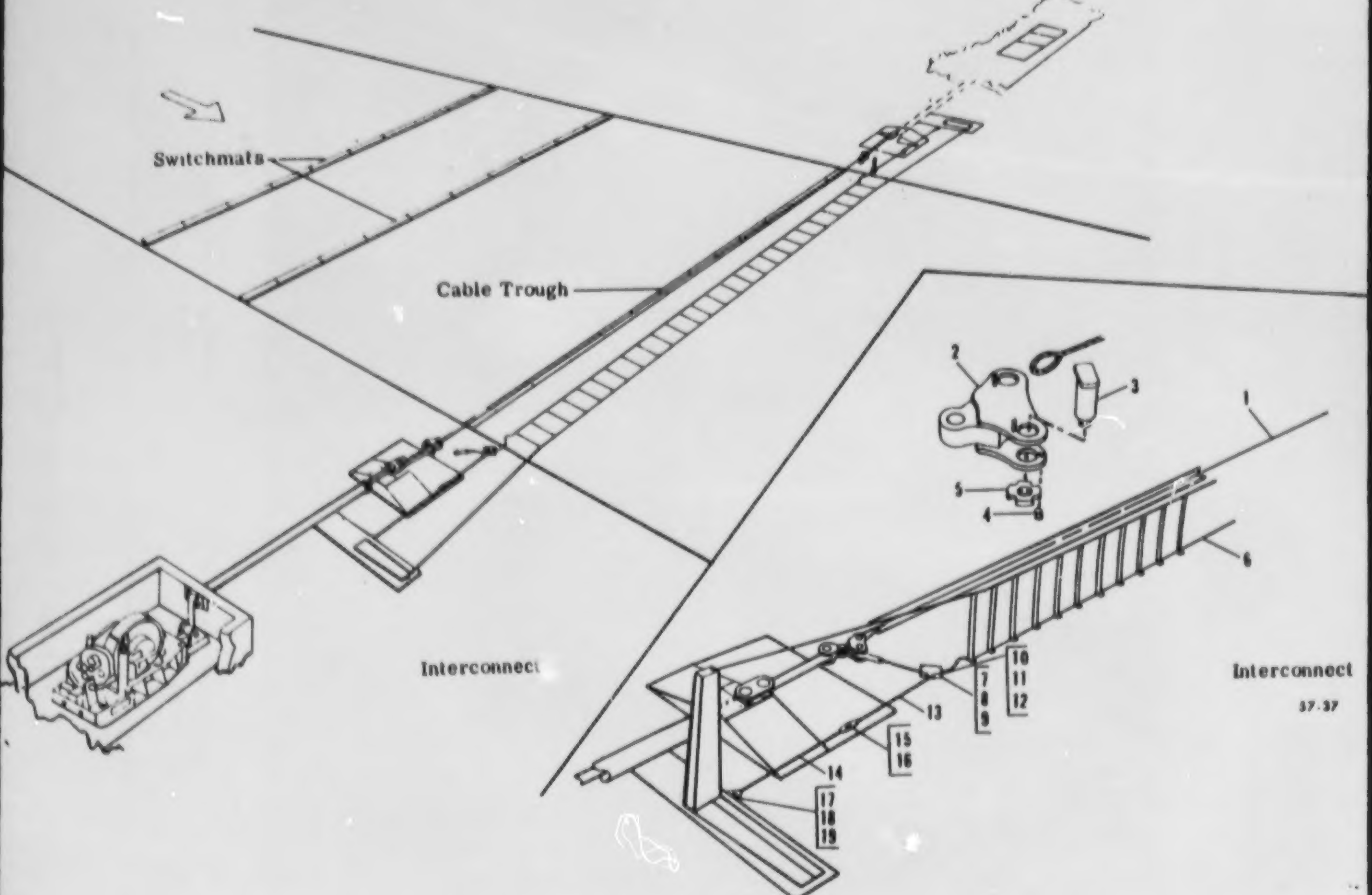
A. Rewind side

1. Chain guard
2. Reel assembly
3. Rewind engine
4. Rewind sprockets
5. Engine base
6. Gas tank

B. Control side

1. Hydraulic system
2. Rewind clutch handle
3. Brake coolant system
4. Chain guard
5. Tape lead-off sheave
6. Instrument panel
7. Battery

Figure 8-17. Arresting engine.


Switchmats
Cable Trough
Interconnect
Interconnect
37-37
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2
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4
5
6
6
7
8
9
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13
14
15
16
17
18
19

1. Dacron tensioning cable
2. 3-way connector
3. Pin
4. Set screw
5. Nut
6. MA-1 pendant cable
7. Cable clamp (lower)
8. Cable clamp (upper)
9. Screw
10. Screw
11. Nut
12. Washer
13. Cable pendant
14. Cable pendant extension
15. Bolt
16. Nut
17. Screw
18. Nut
19. Washer

Figure 8-18. Air-lifted pendant and webbing assembly interconnect system.

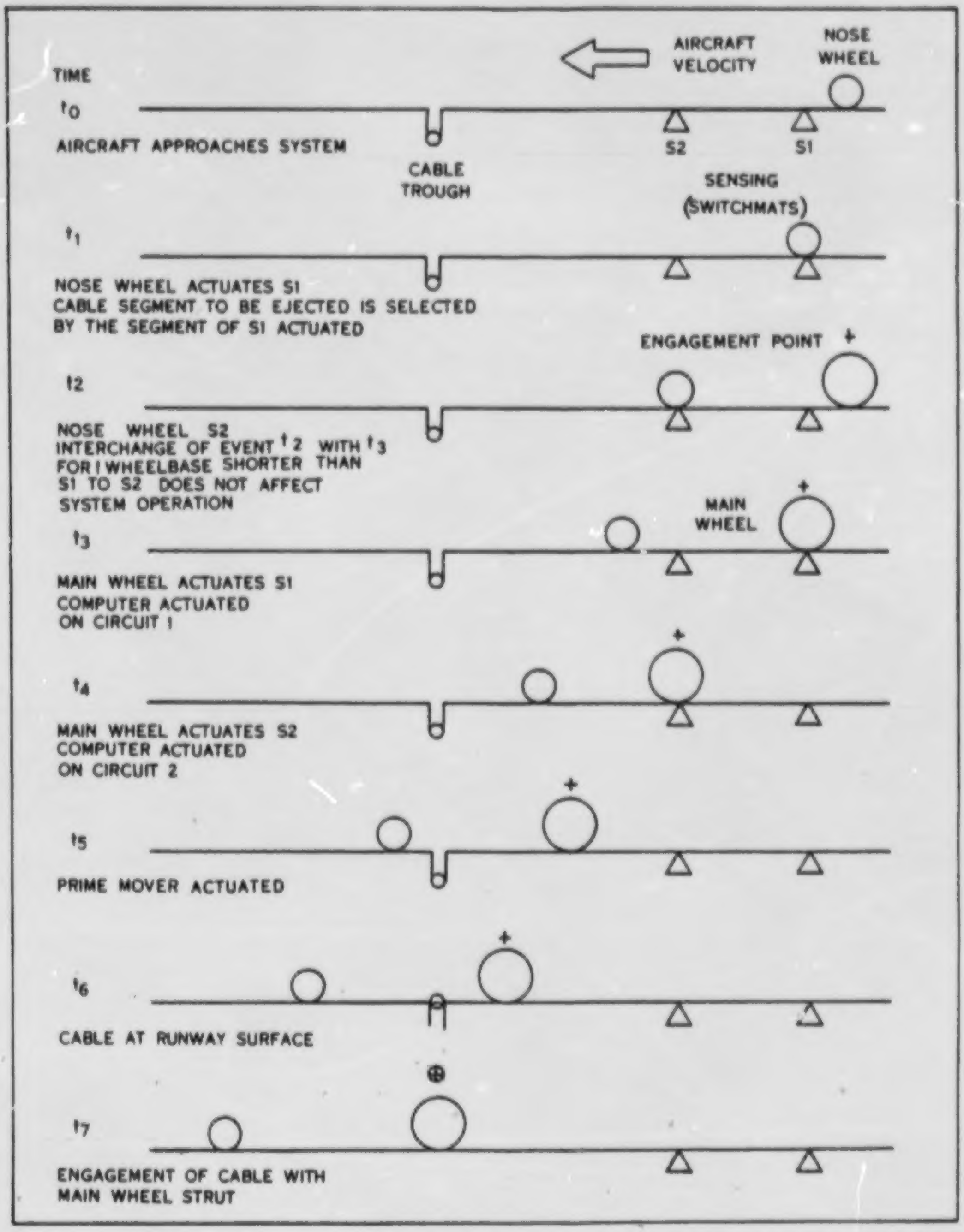
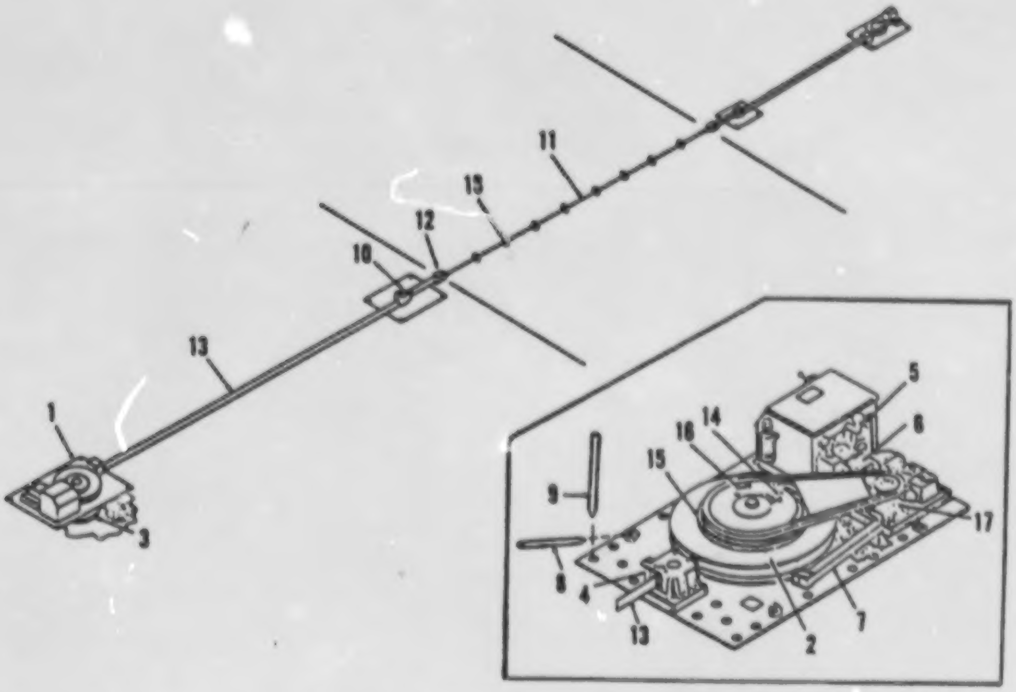

AIRCRAFT VELOCITY
NOSE WHEEL
TIME
t_0
AIRCRAFT APPROACHES SYSTEM
CABLE TROUGH
S2
S1
SENSING (SWITCHMATS)
t_1
NOSE WHEEL ACTUATES S1
CABLE SEGMENT TO BE EJECTED IS SELECTED
BY THE SEGMENT OF S1 ACTUATED
ENGAGEMENT POINT +
t_2
NOSE WHEEL S2
INTERCHANGE OF EVENT t_2 WITH t_3
FOR WHEELBASE SHORTER THAN
S1 TO S2 DOES NOT AFFECT
SYSTEM OPERATION
MAIN WHEEL
t_3
MAIN WHEEL ACTUATES S1
COMPUTER ACTUATED
ON CIRCUIT 1
t_4
MAIN WHEEL ACTUATES S2
COMPUTER ACTUATED
ON CIRCUIT 2
t_5
PRIME MOVER ACTUATED
t_6
CABLE AT RUNWAY SURFACE
t_7
ENGAGEMENT OF CABLE WITH
MAIN WHEEL STRUT
57-36

Figure 8-19. Sequence of engaging events.



37-38

1. Absorber base
2. Storage reel assembly
3. Turbine
4. Lead-off sheave assembly
5. Rewind engine
6. Transmission
7. Tight wrap roller arm
8. EAW-20 explosive earth anchors
9. Stake
10. Runway edge sheave
11. Pendant
12. Purchase tape connector
13. Purchase tape
14. Spring release lever
15. Capstan
16. Engaging lever
17. Gear reducer
18. Pendant support discs

Figure 8-20. Turbine type arresting barrier.

So far you have studied some of the different types of aircraft arresting barrier configurations; now you will read about some of the barrier maintenance problems that you may be required to handle.

Exercises (256):

1. What major components make up the turbine type barrier?

2. What type liquid is used in the turbine energy absorber?

3. How does adding glycol to the water improve the energy absorber?

4. What type devices may be installed on the turbine energy absorber to rewind the tapes?

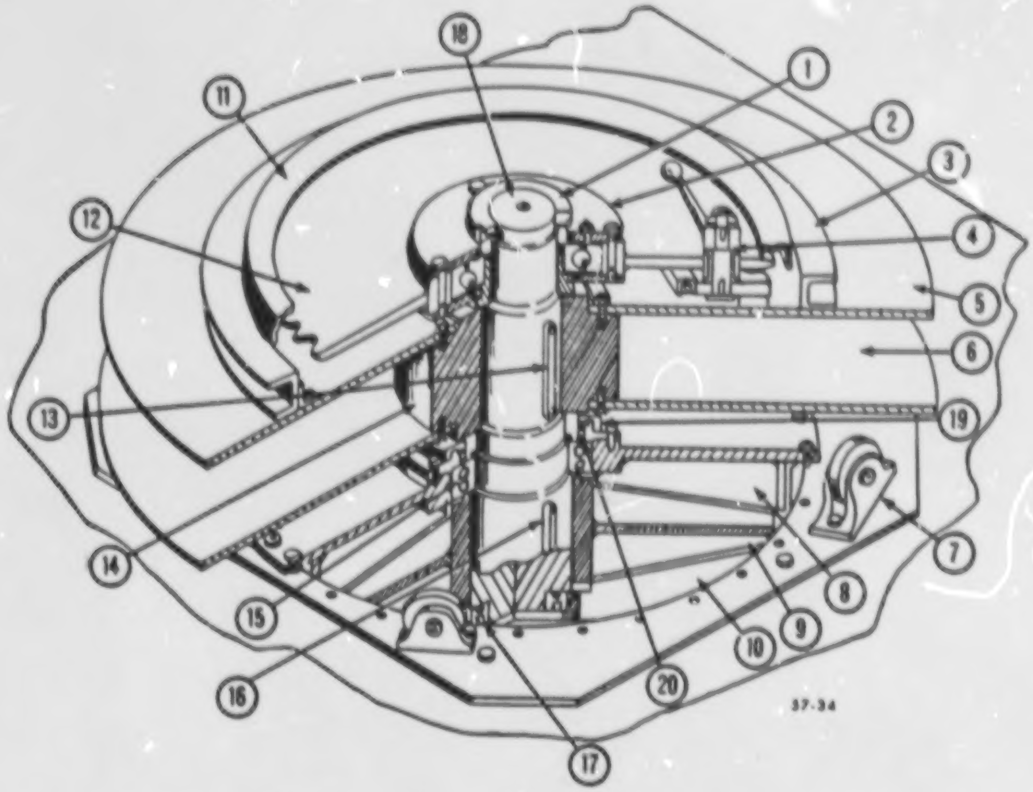
5. If the rewind power unit fails, what may be used to manually rewind the tapes on the turbine energy absorber?

6. How are tight-wrap roller arms released to place the barrier in the battery position?

8-2. Barrier Maintenance

Maintenance of the aircraft arresting barrier is extremely important. The finest equipment will operate no better than its maintenance permits. Therefore, you must do every maintenance task precisely and in exact accordance with the applicable TO. Remember, the pilot's life may be endangered and the equipment destroyed if your barrier is not maintained properly.

Aircraft arrestment can be controlled precisely only when all the systems of an aircraft arresting barrier have been properly inspected, serviced, and maintained in a ready position. Inspection, operation, and maintenance requirements are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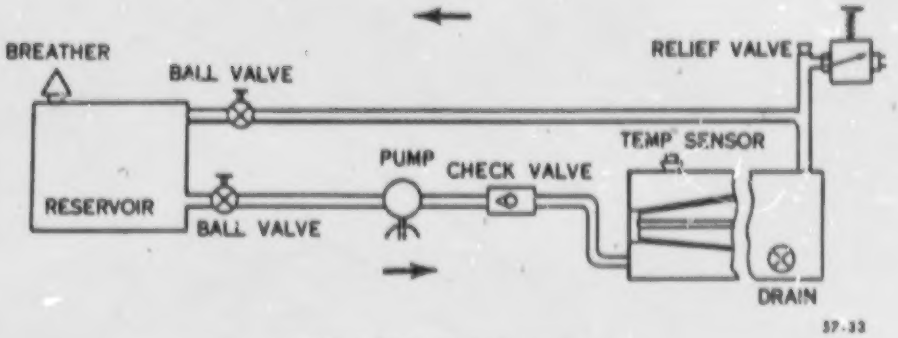
17

37-34

1. Lock nut
2. Sprocket roller bearing
3. Capstan
4. Engaging lever
5. Upper reel side plate
6. Lower reel side plate
7. Roller
8. Upper stator vanes
9. Rotor vanes
10. Lower stator vanes
11. Chain guard
12. Rewind sprocket
13. Hub key
14. Tape reel hub
15. Turbine upper bearing
16. Rotor key
17. Turbine lower bearing
18. Turbine shaft
19. Packing gland nut
20. Packing gland

Figure 8-21. Turbine assembly.


BREATHER
BALL VALVE
RELIEF VALVE
TEMP SENSOR
PUMP
CHECK VALVE
RESERVOIR
BALL VALVE
DRAIN

37-33

Figure 8-22. Coolant system.

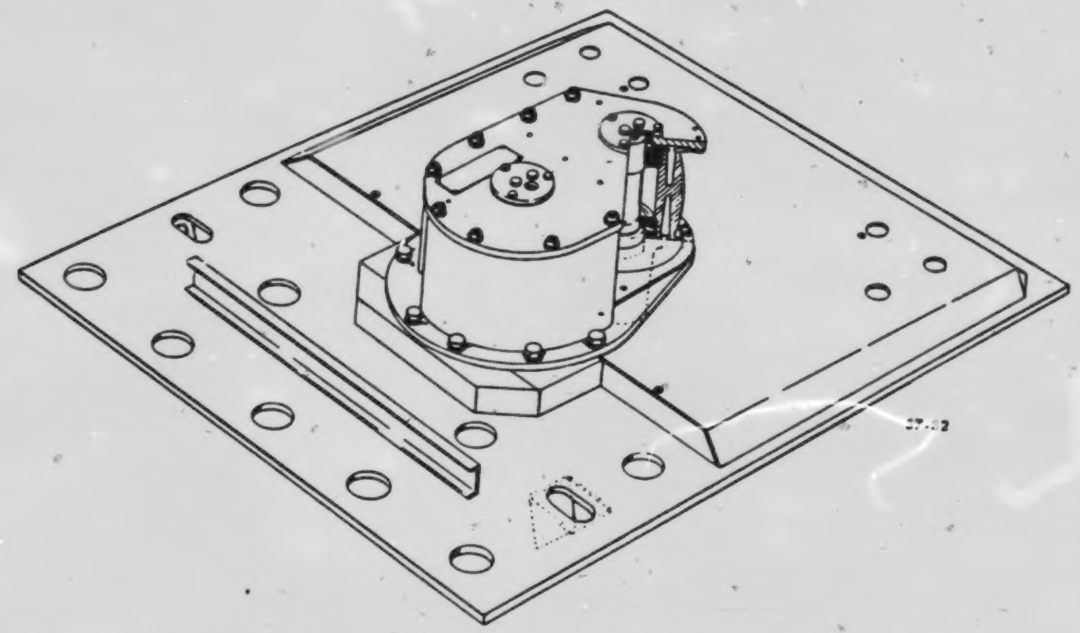


Figure 8-23. Runway edge sheave assembly.

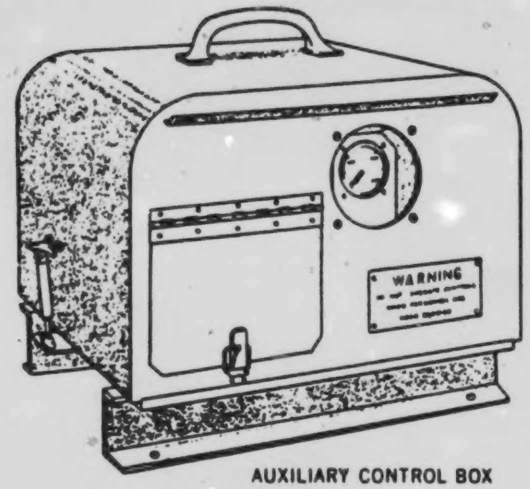
explained in general in this volume of your CDC; however, you must use the current technical order to insure proper maintenance procedures for your particular system. Information given here should be considered as typical. It *cannot* be used to inspect, repair, or replace a component or system of any barrier. Remember that the appropriate, current technical order is your official inspection and maintenance guide.

257. Describe the pneumatic system and give the basic steps for maintaining chain type aircraft arresting barriers.

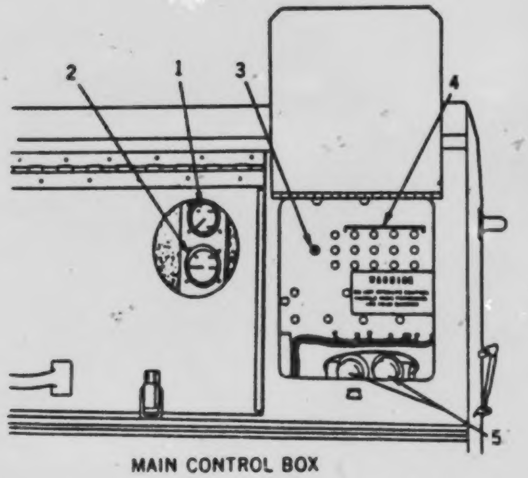
Compressed Air Systems. The chain type barrier uses compressed air to operate the main stanchions of the engaging system. The webbing assembly, as shown in figure 8-1, is connected to these stanchions. Looking at figure 8-1, you see a main control box on one side of the runway and an auxiliary control box on the opposite side of the runway. These control boxes are shown in figure 8-24. The main control box houses two compressors, two accumulators, high and low air pressure gages, and a four-way solenoid valve. The auxiliary control box houses an accumulator, air pressure gage, and a four-way solenoid valve. Compressed air is used to raise or lower the stanchions. You see in figure 8-25 a schematic of the system. On the right are two aircraft-type, high-pressure air compressors and accumulators, and on the left an accumulator. Two actuating cylinders, one on each side of the runway, raise and lower the main stanchions. Electrically controlled four-way solenoid valves control the actuating cylinders. The compressors charge the accumulators to 1500 ± 50 psig. On the discharge side of the accumulators, regulators lower the pressure to 200 psig on some barriers and 150 psig on other barriers. This low-pressure air is used to operate the actuating cylinders.

The compressors are powered by two 12-volt storage batteries. The batteries are connected in series to provide 24 volts to operate the system. They are charged by a selenium rectifier, operating on ac power.

You must inspect the equipment daily to determine its operational status. You must take hydrometer readings of the batteries; check the rectifiers for proper current output; and raise and lower main stanchions several times, using the manual controls (fig. 8-24) on the main control box to lower the accumulator air pressure. Check to see that air compressors start running at approximately 1250 psig. They should charge the system to 1500 ± 50 psig in approximately 12 minutes and then shut off. If this time exceeds 15 minutes, leakage is indicated, either back through the compressor or in the system. To make a leakage check, check the lines first. If no leak is found, troubleshoot the compressor in accordance with the applicable TO. See that the compressor oil level is approximately 1½ inches from the top of the reservoir and not above the lower step of the reservoir. Check the air pressures of the systems for the values specified in the TO. The low



AUXILIARY CONTROL BOX



MAIN CONTROL BOX

37-28

1. Low pressure gage
2. High pressure gage
3. Toggle switch
4. Circuit breakers
5. Manual controls

Figure 8-24. Main and auxiliary control boxes.

pressure is adjustable on the pressure-reducing valve, and the high pressure is adjustable on the pressure cutoff of the compressor.

Webbing Assemblies. Raise the stanchions, thereby placing the barrier in operating position. Inspect each lifter strap for frayed grommets, defective snaps, incorrect rigging to cable, or other indications which, as a result of runway traffic, may render the barrier ineffective. Check the actuator straps for condition and correct tension with webbing height (see manufacturer's manual). Also inspect the shear pins and fittings for security.

Replace all nylon webbing every 60 days, if it is not damaged sooner. Heat weakens nylon. For this reason you should not use excessive heat to thaw frozen webbing. To prevent the webbing from freezing to the runway, spray or soak it in deicing fluid. To compensate for stretching of the webbing assembly during periods of continuous rainfall, make a minimum of two daily inspections and an inspection immediately following a period of severe rain or heavy downpour. To prevent failure of the shear pins during engagement, be sure to relieve the tension as the webbing dries.

Arresting Cable and Supports. Check the arresting cable and supports (see fig. 8-1) for serviceable condition and replace any arresting cable that has four or more broken wires (in all strands) within the length of one rope lay. A lay is one complete revolution of a strand around the core of a wire rope. If kinks appear after 10 engagements, or after 18 months of service, the cable must be replaced. Be extremely careful when you work with unserviceable cables so that you will not cut your hands and legs.

Since the pendant must be supported properly to engage the aircraft tail hook, you must replace any pendant support discs that are worn excessively. The typical time for disc replacement would be when the pendant is held less than 2 inches above the runway surface. Figure 8-26 shows the pendant being supported by the discs. When the discs are worn out, remove all of them and install new ones, as illustrated in A, B, C and D. Lubricate each disc hole with vasoline or another suitable lubricant, and install the discs over the pendant cable, using the 2-inch tube and arbor as shown. Space the discs properly, reconnect the pendant, and pre-tension it to return the barrier to the battery position.

When you replace cables, be careful as you remove the new cable from a box or reel. If you handle the cable improperly at this time, the rope may spiral and kink. You can never rely on kinked rope to render normal service, because both abrasion and fatigue are apt to develop rapidly at the damaged spots. Be sure to lubricate all exposed cables with a lubricant recommended by the applicable technical order.

Stanchions. The main and the intermediate stanchions are different in construction and in purpose. The main stanchions are supports for the webbing at the sides of the runway, while the intermediate stanchions support the webbing over the runway. The two types require different maintenance procedures.

The main stanchions have double-acting pneumatic cylinders to raise and lower the webbing assembly. Since these units are operated by air pressure from the main control box, maintenance is largely a matter of checking and repairing air leaks. Keeping the stanchions clean is another service you must not overlook. Lubricate the cylinders and check them for corrosion.

Each main stanchion has a hand-operated winch

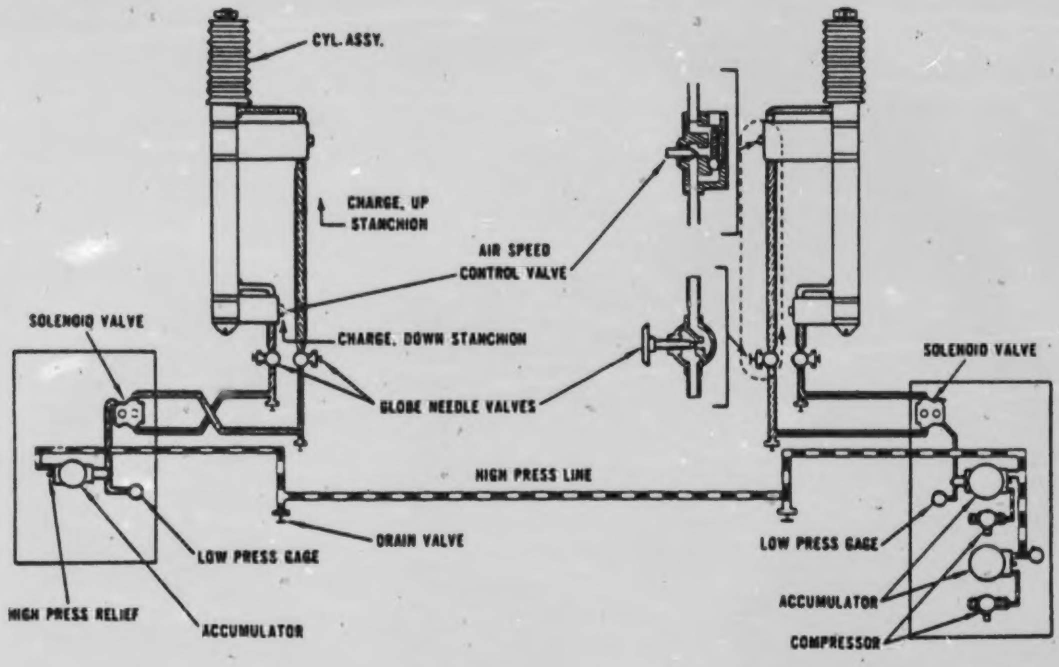


Figure 8-25. Compressed air system schematic.

to position and pretension the webbing assembly. Inspect these units for proper operation and replace any components that are worn beyond the specified limits. Lubricate the unit as necessary. Sometimes the cylinder bumpers and restrictor valve assemblies must be replaced because of excessive wear.

The intermediate stanchions, made of steel tubing, support the webbing assembly over the center of the runway. Since they are on the runway, they frequently become damaged during engagements and must be replaced. They are designed with a hinge arrangement at the base where they attach to the runway so that they can yield to the impact of the aircraft. Inspect the intermediate stanchions after each engagement for bent or broken components. Make repairs as necessary. The actuator straps are made to disassemble upon engagement with the aircraft, but they are also sometimes damaged. You should inspect them for serviceability. If they are damaged, replace them.

Main Control Box. The main control box consists of a number of different units; therefore, varied maintenance is required. The units that are housed in this box are the air compressor, panel assembly, rectifier, a set of storage batteries, and related parts. Probably, the maintenance that you must perform most often is that required by the storage batteries. Check the level of the electrolyte and add distilled water if necessary. Keep the terminals and cables clean and tight. Since there are so many electrical components in the control box, all electrical connections must be kept tight and free from corrosion. The air compressor will require very little maintenance, as it is of the self-contained type.

Plumbing. Particular maintenance must be given to the pneumatic piping between the main control box, auxiliary control box, and stanchion cylinders. Inspect the connections for air leaks, and inspect metal tubing and pipes for abrasion and corrosion. Also check the flexible composition tubing at the stanchion cylinders for deterioration, breaks, and cracks.

Auxiliary Control Box. This box usually has a high-pressure air accumulator, a pressure gage, and a four-way solenoid valve that controls airflow to the cylinders of the main stanchions. Very little maintenance is performed on this box, except checking for air leaks at the accumulator connections and the piping leading to the main control box and main stanchions.

Exercises (257):

1. In a few sentences, describe the pneumatic system for raising and lowering the main stanchions of the chain type barrier.

144

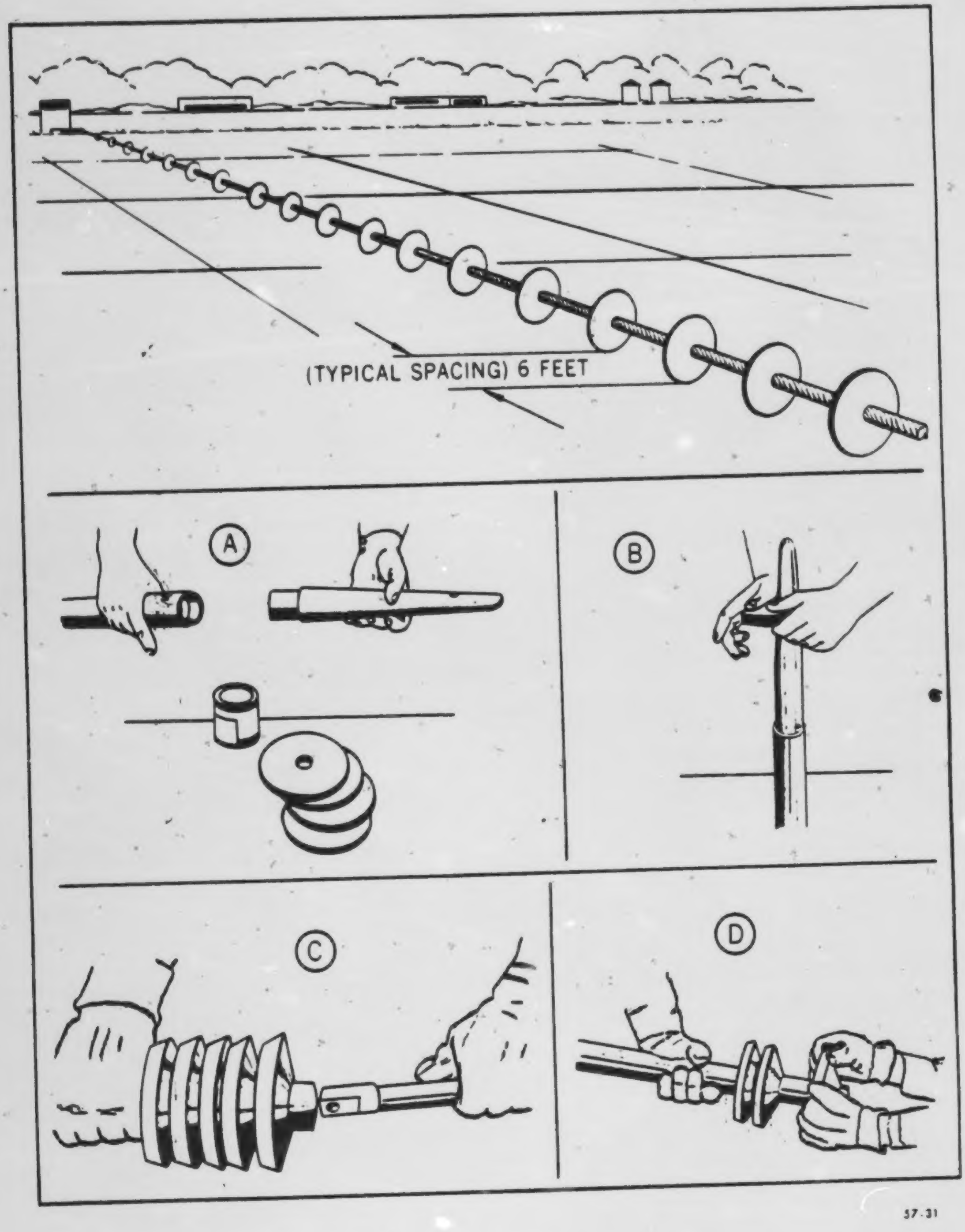

(TYPICAL SPACING) 6 FEET
A
B
C
D
57-31

Figure 8-26. Runway pendant and support discs.

2. What is indicated if the air compressors of the chain type barrier require more than 15 minutes to raise the pressure from 1250 to 1500 psig?

3. How should you free a webbing assembly that is frozen to the runway?

4. What is one rope lay?

5. What is the maximum replacement time for a runway pendant?

6. What is the typical requirement for replacing the runway pendant support discs?

7. In handling a new pendant during installation, you should be careful to avoid what development in the cable?

8. How often should the intermediate stanchions of the webbing assembly be inspected?

258. Tell how or when maintenance requirements/operations are accomplished for aircraft arresting barriers.

Pendant Cable Assemblies. You should inspect the cable to see that it is positioned correctly in the supports and that it is supported at the proper height on the runway. If the cable is on the active runway and subject to taxi traffic, or if aircraft pass over it on landing and takeoff, more frequent inspections may be required. Inspect the webbing pendant to insure the correct slack position.

A runway pendant must be replaced when an inspection reveals that:

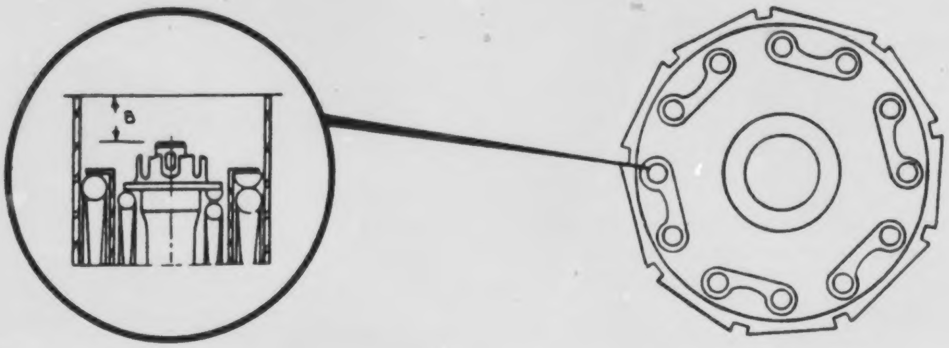
- Four or more broken wires (in all strands) are within the length of one rope lay.
- It has been in service over 18 months.
- A sharp kink cannot be removed readily by pretensioning the cable.

Replace the pendant cable supports as required and space them as the applicable technical order recommends.

Sheave Assemblies. Inspect sheaves for free rotation. It is possible that the purchase tape may carry so much sand and dirt into the sheave during a retrieve that tape and sheave will bind in the cover assembly. If this is the case, it may be necessary to remove the covers and clean out the foreign matter. When the dirt is not packed too tightly, you can flush out the foreign matter with water under pressure. When the sheave cover is removed, check the bearings for wear. If the wear is beyond the limits recommended by the manufacturer, replace the bearings. Lubricate them as required. Inspect the sheave rub block for serviceable conditions. If the purchase tape has worn it beyond the maximum limit specified by the manufacturer, replace it.

During retrieve operations, take care not to allow the cable to kink. A kink can cause severe damage to the cable. If a kink has been tightened, the cable is permanently damaged and must be replaced. If a tape carries sand or dirt into the sheave so there is danger of jamming, stop the retrieving operation immediately to prevent damage to the sheave or housing.

Brake Cooling Systems. The inspections and maintenance performed on absorber cooling systems depend upon the type of system. Inspect a water/glycol solution system for solution leaks in the piping, water pump, and various connections. See that there is enough solution and that it is clean. If the pump packing leaks more than an occasional



57-30

Figure 8-27. Brake wear measurement.

drip, it should be repacked. Inspect the pump belt for wear.

Arresting Engine Assembly. The arresting engine is the device that absorbs the energy of an engagement. Looking at figure 8-11, you will see an outline drawing of the barrier in its standard (expeditionary) installation. An arresting engine is installed at each end of the arresting gear assembly. The arresting engine includes a rotary friction type brake. It is essentially a B-52 aircraft, multiple-disc, hydraulic brake, modified for use with the barrier. Proper lubrication of the arresting engine is a very important preventive maintenance function. The normal life-span of a mechanical system depends on proper lubrication.

Brake wear measurement is important in the maintenance of the arresting engine. Although this is a multiple-disc type brake, its linings wear out in much the same way as do the brakes of an automobile. On the B-52 type brake, an adjuster pin indicates brake wear, as shown in figure 8-27. A typical maintenance requirement would be when dimension "B" is ½ inch; brake replacement should be scheduled for the next convenient maintenance period. When wear has reduced, the measurement to 9/16 inch, brake replacement is mandatory.

Purchase Tape Assemblies. The purchase tape must withstand the same tension as the runway pendant during an arrestment, Therefore it must, be carefully inspected after each arrestment and must be maintained in serviceable condition. Since TO criteria for the maintenance and replacement of the tape is subject to change, the following should be considered as typical maintenance and replacement data.

The tape exposed to the atmosphere and sunlight is subject to deterioration. To preclude possible breakage, the tape extending from the runway edge to the tape connector must be cut off (cropped) and discarded at 6-month intervals or after six engagements, whichever occurs first.

The tape that is pulled out during an arrestment wears faster than the other end of the tape, which is fastened to the tape reel. To distribute the wear more equally, remove the tape from the reels after 15 to 18 arrestments, turn it end for end, and replace it on the reels.

CAUTION: After you replace the tape, inspect all tubes to see that the tape is in a flat position. Only the tapes from the runway sheaves to the pendant end should be at a 90° angle to the runway surface. After cropping or after end-for-end switching of the tapes, you must reset the cam zero index so that it is on the follower when the pendant is pretensioned. You also must check the tape stack height.

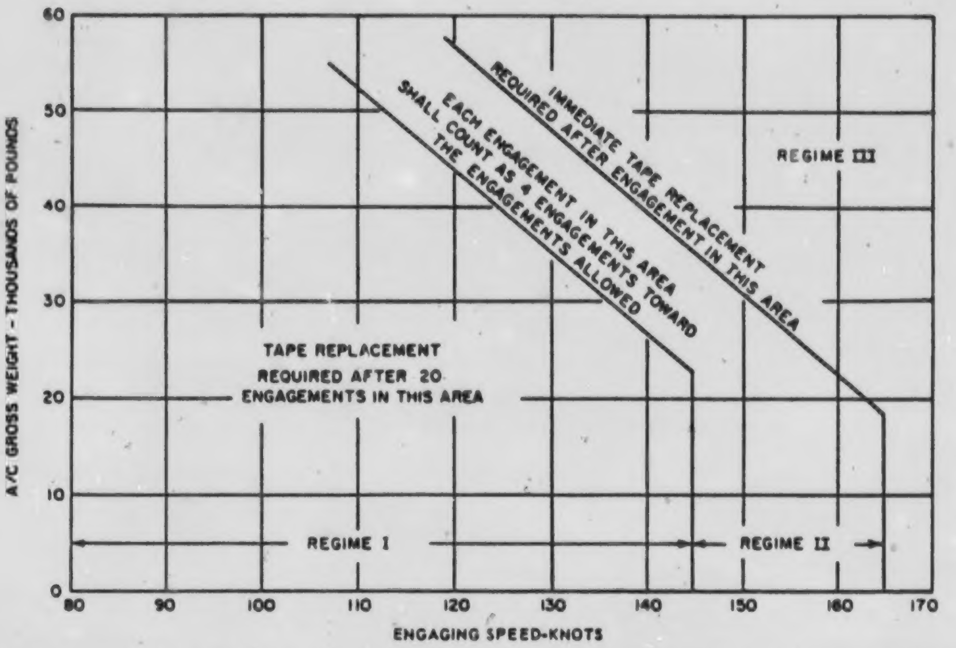
You must replace the tape when it becomes too short, is damaged physically, or exceeds engagement criteria. Typical examples of these conditions for one type of barrier would be: (1) less than 55½ inches stack height on tape reel; (2) damage, such as a lateral cut through the case into the longitudinal fibers, abrasion to the case into the longitudinal fibers, abrasion to the case exposing two adjacent longitudinal fibers or bundles, or edge abrasion exposing the first longitudinal bundle; (3) anything exceeding the criteria shown in figure 8-28.

Looking at this figure, you see that 20 engagements in regime I area necessitate tape replacement. Each engagement in regime II would be counted as four engagements. Immediate tape replacement would be required for any engagement in regime III. Note that the engaging speed and aircraft gross weight are the factors that determine the regime area. Considering an engaging speed at 140 knots, if the gross weight were 20,000 pounds, it would fall in regime I; 30,000 pounds – regime II (counts as four engagements); and 50,000 pounds – regime III (immediate tape replacement).

Hydraulic System. Proper operation of the hydraulic system of the rotary-friction type barrier (fig. 8-10) is essential. The system must apply the correct pressure to the brakes and clutch during aircraft arrestment. Looking at the hydraulic system schematic, you should get a general picture of system operation. In figure 8-6 you can see the various components and plumbing as they appear on the reel and shaft assembly. You must inspect the system after the periods specified in the TO.

After each engagement and rewind, check the brake accumulator for the proper fluid level and aircharge of 175 psig ± 10. Reset the brake system pressure gage to zero. If the fluid level is not visible in the sight glass of the brake accumulator, operate the manual transfer pump to bring the level to not less than half and not more than the top of the glass. If unequal amounts of tape are paid out during arrestment, the pendant will not be centered between the runway edge sheaves after retraction. To recenter the pendant, do the following: (1) Reduce clutch pressure to 50 psig by opening the air charging valve on the clutch accumulator; (2) position one tape connector to the desired final location; (3) drive a vehicle onto the tape adjacent to this tape connector; (4) press the rewind "reverse" button to rewind tape; (5) release the button when the other tape connector is in its proper final position; (6) remove the vehicle from the tape; (7) recharge the clutch accumulator with compressed air to 800 psig (+200-0); pretension the pendant as explained previously.

The system must be inspected daily. When you perform this inspection, you must check the fluid level in the sight glass of the fluid reservoir. The level should be approximately centered in the glass. If any fluid is needed, add hydraulic oil MIL-H-5606A (red color-petroleum base) by removing the breather cap on top of the reservoir. Check the brake accumulator for the proper fluid level and adjust the level if necessary. Check clutch accumulator for



NOTE: EACH TAPE PULLOUT/REWIND CYCLE MADE TO COMPLY WITH SECTION 2-14 MONTHLY INSPECTION SHALL COUNT AS 1/2 ENGAGEMENT.

EXAMPLE: TAPES IN SERVICE 18 MONTHS – COUNT 9 ENGAGEMENTS.
ONE (1) ENGAGEMENT IN REGIME II – COUNT 4 ENGAGEMENTS.
SEVEN (7) ENGAGEMENTS IN REGIME I – COUNT 7 ENGAGEMENTS.
TOTAL COUNT 20 ENGAGEMENTS – REPLACE TAPES.

Figure 8-28. Purchase tape replacement criteria.

proper pressure and charge with compressed air if required.

In addition to the daily, weekly, and monthly inspections, a more comprehensive, semiannual inspection must be made. This type of inspection includes the inspection items of the daily, weekly, and monthly inspections, and some additional items. To perform this inspection, you would follow the exact procedure specified in the TO.

Rewind System. The rewind system of the permenantly installed, rotary friction type barrier includes a special high-torque electric motor, as shown in figure 8-7. The motor is designed to rotate in both a forward and reverse direction. A two-button station control is used to operate the motor, as you see in figure 8-7. The system is designed to use 3-phase, 60- or 50-cycle electrical power. The motor is of the dual voltage type; that is, it can be operated from 220 or 440 volts by simply changing the internal connections. Power is applied to the motor during system operation by the full voltage-reversing starter. The pushbutton station has two momentary-contact pushbutton control switches.

Exercises (258):

1. What inspection criteria are used to determine if a runway pendant cable requires replacement?

2. If dirt is not packed too tightly in a sleeve assembly, how can you remove it?

3. What should you check when you inspect a water/glycol solution system?

4. On the rotary friction type barrier, how would you determine when the brake disc linings are worn excessively?

5. What time period is specified for cropping the purchase tape?

6. What must be done to distribute the wear evenly over the entire length of the purchase tape?

7. At what location would the purchase tape be at a 90 degree angle to the runway surface?

8. Name two things you must do after cropping, or end-for-end switching, of the tapes.

9. What would be the maintenance requirement, if any, where an arrestment was computed to fall in regime III of the purchase tape replacement graph?

10. Outline the maintenance tasks necessary to correct for unequal payout of the tapes during an arrestment by the permanently installed rotary friction model barrier.

11. How often must you inspect the hydraulic system of a barrier?

12. What should you do if you discover that the clutch accumulator has low pressure?

13. When should your most comprehensive inspection of a barrier be made?

14. You must have the electrical power supply for a permanently installed rotary friction type barrier checked. The report from the electric shop must show that what power is available for the rewind system to operate properly?

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AFM 127-201, *Missile Accident Prevention.*
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TO 35E8-2-4-1, *Arresting Gear, Aircraft, Model BAK 9/F48A.*
TO 35E8-2-5-1, *Aircraft Arresting Systems, Model . BAK-12/E32A.*
TO 35E8-2-7-1, *Aircraft Arresting Barrier, Model BAK-13/F481A.*

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NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB AL 36112, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs*. TOs, classified publications, and other types of publications are *not* available. Refer to current indexes for the latest revisions of the changes to the official publications listed in the bibliography.

NOTE: Page Number 150 has been omitted.
However, all course material is included.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

200 - 1. The fourth element of the tetrahedon fire explanation is known as chemical reactivity, or a chemical chain reaction.
200 - 2. There is not sufficient oxygen to react with the hydrocarbon particles.
200 - 3. A typical poisonous smoke contains combustion products composed of the atoms and molecules that formed the poisonous fuel, together with the oxidizer that supported the combustion.
200 - 4. So you will be able to make intelligent firefighting decisions.
200 - 6. The ease of burning depends on the state of the metal.
200 - 5. As a Class A or B fire, depending on the material(s) involved within the motor.
200 - 7. The substance is heated to the point where vapors are given off. The heated vapors then mix quickly with oxygen in the air, and fire results.
200 - 8. It means that the substance is two-and-a-half times as heavy as air under the same conditions of pressure and temperature.
200 - 9. (a.) at all levels; (b.) at the lowest levels; (c.) at the highest levels.
200 - 10. The surface area of fuel exposed to the air.
200 - 11. The term "flashpoint" is used to express the condition of a fuel vaporizing, whether or not it is vaporizing fast enough to keep burning.
200 - 12. Autoignition (self ignition) will occur.
200 - 13. The upper explosive limit.
200 - 14. Spontaneous heating and ignition start as a result of chemical reaction within the material.
200 - 15. Usually, there is enough air to allow oxidation, but not enough air to carry the heat from the area.
200 - 16. The transmission of heat to nearby materials.
200 - 17. The coldest air would be nearest the floor because warm air is lighter and rises, forcing the colder air downward.
200 - 18. The amount of oxygen present.
200 - 19. Oxidizing agents are chemical compounds which, when heated or when in contact with water, give off oxygen which, in turn, supports the burning of flammable materials.
200 - 20. The more common oxidizing agents are the nitrates, chlorates, and peroxides.

201 - 1. When the water is broken into fine particles to accelerate the heat absorption.
201 - 2. Excludes the oxygen from the fuel so that gases or vapors of the fuel cannot ignite and continue the combustion.
201 - 3. Separation.
201 - 4. Interruption of the chemical reaction.

202 - 1. Its outstanding heat absorbing qualities.
202 - 2. The burning material (its temperature) and the manner in which the water is applied (straight or fog stream).
202 - 3. Its nonconductivity.
202 - 4. Dissipation of carbon dioxide after apparent extinguishment allows hot surfaces or embers to reignite material.
202 - 5. The additives improve the storage, flow, and water repellency of the powder.
202 - 6. Above 140° F., there may be some sticking or caking.
202 - 7. Dry powder agents.
202 - 8. Primarily by keeping air from reaching the combustible metal.
202 - 9. As with any other agent, the application determines its effectiveness.
202 - 10. The vapor-sealing effect prevents the release of fuel vapors which could result in flashbacks.
202 - 11. Halon 1211 requires pressurization to expell it at a satisfactory rate for extinguishment.
202 - 12. Halon 1301 is treated as a liquefied gas.
202 - 13. (1) a, e.
(2) a, b, c, e, f.
(3) b, c, f.
(4) d.

203 - 1. A gas. (27 psi + 14.7 psi = 41.7 psia)
203 - 2. Flammable liquids are those liquids with a flash-point below 100° F. and a vapor pressure not over 40 psia at 100° F.
203 - 3. Combustible liquids are those liquids with a flashpoint at or over 100° F.
203 - 4. Gases are classified by their chemical or physical properties and usage.
203 - 5. Combustible solids are solids which ignite, burn, and change chemically when subjected to heat or fire.
203 - 6. Most of the fire hazards associated with combustible metals are found in the manufacturing process.

204 - 1. Ordinary plywood.
204 - 2. It may heat rapidly, lose its strength, and deform.
204 - 3. The asphalt may melt and run, spreading the fire rapidly.
204 - 4. The surface may crack or spall with near-explosive force and destructive effect on the wall.
204 - 5. Their combustibility varies according to the type of plastic used as a binder.
204 - 6. Gypsumboard.
204 - 7. Bakelite, poly-vinyl plastic, and celluloid, in that order.
204 - 8. Generally, acoustical and insulation materials composed of animal or vegetable materials are combustible.
204 - 9. The two general types are surface coatings and impregnation.
204 - 10. Magnesium and titanium.

CHAPTER 2

205 - 1. False. Change "all but" to "only."
205 - 2. True.
205 - 3. False. Change "mass fire" to "blast."
205 - 4. False. Change "2, 3, 4, and 6" to "3, 4, 5, and 6."
205 - 5. True.
205 - 6. False. Change "1.2" to "1.3."
205 - 7. False. Change "and they produce" to "and they do not produce."
205 - 8. False. Change "and" to "but no."
205 - 9. True.
205 - 10. True.
205 - 11. False. Change "assignments, which" to "assignments." Delete remainder of the statement.

206 - 1. (1) h.
(2) a.
(3) l.
(4) d.
(5) b.
(6) g.
(7) m.
(8) i.
(9) f.
(10) n.
(11) k.
(12) e.

207 - 1. 1; octagonal; orange; black.
207 - 2. 1.2; blast; fragment; 2.
207 - 3. Fire Symbol 3.
207 - 4. 4; moderate.
207 - 5. 1; 4; cross-shaped.
207 - 6. Chemical agents.
207 - 7. Circular; blue; red.
207 - 8. Yellow.
207 - 9. A chemical hazard symbol with WHITE rim and figure will be displayed.
207 - 10. The symbol is a 24-inch circle with a blue background. There is a white rim, one-half inch wide, around the blue background, and there is a figure of a person wearing a gas mask (in white) centered on the symbol.
207 - 11. The presence of materials for which water is not a suitable extinguishing agent.
207 - 12. On doors and lockers *inside* buildings or hangars.

208 - 1. False. Change "method of application" to "purpose."
208 - 2. True.
208 - 3. False. Change "Choking gases" to "Blister agents."
208 - 4. False. Change "blister agent" to "choking gas."
208 - 5. True.
208 - 6. False. Change "hydrocyanic acid" to "cyanogen chloride."
208 - 7. True.
208 - 8. True.
208 - 9. False. Change "harmless" to "poisonous," and "poisonous" to "harmless."
208 - 10. True.
208 - 11. True.
208 - 12. False. Change "fine powder magnesium" to "metallic sodium or WP."

209 - 1. False. Change "will be a hazard" to "will NOT be a hazard."
209 - 2. True.
209 - 3. True.
209 - 4. False. Change "one-half hour" to "an indefinite period."
209 - 5. False. Change "an accident/incident" to "fire."
209 - 6. False. Change "great" to "very little."
209 - 7. False. Change "but will not" to "and may readily."
209 - 8. False. Change "radioactive material" to "high explosives."
209 - 9. True.
209 - 10. False. Change "beta" to "alpha."
209 - 11. True.

210 - 1. Bacteria, viruses, and fungi.
210 - 2. Toxins are poisonous byproducts of living animals and plants. Bee strings, snakebites, and food poisoning are some examples of poisonous byproducts of living animals, while poison oak and poison ivy are poisonous byproducts of plants.
210 - 3. Plant growth regulators and defoliators.
210 - 4. By a color and letter code – the color code is used to designate the use of the weapon and the letter code to designate the filler.
210 - 5. To a large degree wind and weather conditions control the area that will be contaminated.
210 - 6. The heat generated by large enough amounts of HE to present a hazard to life, would in itself destroy most of the living agents or toxins.
210 - 7. By wearing full protective clothing and breathing apparatus, and by approaching and combating the fire from upwind.

211 - 1. (1) f, p.
(2) i, m, n.
(3) l.
(4) i, m, n.
(5) a.
(6) q.
(7) o.
(8) g, h, t.
(9) k (b,c,e,g,h,i,j,m,n,s,t).
(10) c.
(11) e, j, s.
(12) b.
211 - 2. (1) d.
(2) a.
(3) g.
(4) p.
(5) f.
(6) k.
(7) o.
(8) n.
(9) l.
(10) b.

212 - 1. Specialized recovery personnel.
212 - 2. All exposed clothing, apparatus, and equipment.
212 - 3. The best decontamination procedure is the least expensive procedure that will reduce the hazardous concentration of contamination to a safe level within allowable time factors.
212 - 4. (1) d; f.
(2) a; e.
(3) b; c.
212 - 5. Water, earth, and fire.
212 - 6. High wind rapidly disperses the vapors of chemical and biological agents.
212 - 7. Puddles; they may contain high concentrations of insoluable contaminants.
212 - 8. The vaporizing liquid types.
212 - 9. To take a close look at its part in the operation and see how its participation may be improved.

CHAPTER 3

213 - 1. Cartridge operated type.
213 - 2. Correct pressure and condition of the gage.
213 - 3. One seal is attached to the valve handle or wheel to hold the pin in place and the other is over the safety disk.
213 - 4. A missing plastic seal over the safety disk.
213 - 5. When more than 10 percent of the expellent gas is lost from the cartridge.
213 - 6. Dry-chemical.

214 - 1. Service test.
214 - 2. You might test an extinguisher the wrong way.

214 - 3. Because, the failure of the extinguisher could be violent.
214 - 4. Every five years.
214 - 5. It should be destroyed.

215 - 1. Make sure you have the TO or the manufacturer's literature for that extinguisher.
215 - 2. Invert it from its normal operating position and operate the discharge valve.
215 - 3. Replace it.
215 - 4. Give them a full operational test.

216 - 1. Grooving, dryness, and cuts.
216 - 2. Dry nitrogen.
216 - 3. After use, periodically, and when they fall below 90 percent of weight capacity.
216 - 4. Because extremely high pressures are encountered.
216 - 5. The time required to charge an empty clinder increases with the temperature of the cylinder.
216 - 6. To prevent clogging the supply hose with carbon dioxide snow.
216 - 7. So as to transfer liquid rather than gas.
216 - 8. You connect the hose to the recharging adapter.
216 - 9. 49½ pounds (15 pounds net charge plus 34½ pounds cylinder weight).
216 - 10. You must FIRST stop the transfer-unit motor and then close the shutoff valve in the pump outlet hose.
216 - 11. If the transfer pump is not shut off first, it will cause pressure build up and possibly burst the hose or valve.
216 - 12. After the valve is closed, loosen the setscrew of the adjustable ring, or collar, under the handwheel; turn the collar until the holes in the collar and handwheel are aligned.
216 - 13. By using a bypass filling unit.
216 - 14. A difference of temperature, and corresponding difference in pressure between two cylinders.
216 - 15. Bleed off any remaining pressure.
216 - 16. The CO^2 cartridge pressure may decrease so far that it will not expell the agent.
216 - 17. Only the type indicated on the shell.

CHAPTER 4

217 - 1. $P = .434 \times H$.
217 - 2. 56.42 pounds ($P = .434 \times H$) $= .434 \times 130 = 56.42$
217 - 3. 11.5 feet per floor is about average in the Air Force.
217 - 4. 25 pounds ($5 \times 5 = 25$) you don't count the first floor.
217 - 5. The area of the opening and the velocity of the flow.
217 - 6. The constant 29.7 is used to make the formula for computation less cumbersome to work with.
217 - 7. $29.7 \times D^2 \times \sqrt{P}$
217 - 8. 545.73750 or 546 gpm.
217 - 9. The same formula is used but the answer is multiplied by .90 for the final step.
217 - 10. The pressure lost between the source and outlet is the friction loss.
217 - 11. The friction loss will be approximately four times as great.
217 - 12. 91 psi ($EP - NP = FL$) $152 - 61 = 91$
217 - 13. 21 psi ($FL = 2Q^2 \div Q$) $2 \times 3 \times 3 \div 3 = 21$
217 - 14. The changeover valve should be in the pressure, or series, position.
217 - 15. The atmospheric pressure.
217 - 16. A perfect vacuum.
217 - 17. 25 feet.

218 - 1. To explain procedures and geographically important information required during fire-suppression operations.
218 - 2. Copies of each prefire plan are located in the fire alarm communications center. Building prefire plans are also carried on the assistant fire chief's vehicle and on each first-run pumper. Aircraft prefire plans are carried on each fire chief's and assistant fire chief's vehicle.
218 - 3. Each prefire plan must be reviewed at least anually and updated as required.
218 - 4. The specific risk that might be involved for each physical situation.
218 - 5. The availability of equipment. This must be considered because your plan must be made workable using the equipment you have. The third consideration is the personnel available. This will not only include the number of personnel available but also the extent of their training.
218 - 6. So that firefighters will know where the doors, windows, stairways, and fire escapes are; where personnel are expected to be; and the most logical means of rescue.
218 - 7. The stored high-value items, flammable materials, or other special hazardous areas and how best to protect them. The placement of hose streams and distances involved should also be included.
218 - 8. Water supply information should include the location of hydrants or other sources of water along with the pressures and amount of water available. Ladder coverage should include where the ladders are to be placed and the length of ladders required.
218 - 9. Ventilation.
218 - 10. Indicate where the utilities are to be cut off and how and by whom they are to be cut off.
218 - 11. You should make sure that Civil Engineering notifies you of all activities that may affect the prefire plans.

219 - 1. What type of aircraft should I plan for?; How many people are on each aircraft?; What is the proper firefighting and rescue procedure for each type of aircraft?; How much fuel is the aircraft carrying?; and, When and where is the aircraft most likely to experence difficulty?
219 - 2. Each type of mission-assigned aircraft, mission support aircraft, and transient aircraft that land and take off (including touch-and-go landings) an average of seven times a week during any three consecutive months.
219 - 3. The aircraft itself and directives such as TO 00-105E-9.
219 - 4. The predesignated rescuemen's duties are included on the AF Form 1028, PRE-FIRE PLAN.
219 - 5. It will allow you to anticipate the most likely time and place of an emergency.
219 - 6. The amount of equipment available, characteristics of the aircraft, weather, terrain, and runway condition.
219 - 7. Any other equipment on the installation that

may be of assistance during firefighting operations.
219 - 8. Off duty fire protection personnel, auxiliary firefighters, and mutual aid response crews.

220 - 1. False. Change "are the same as" to "differ from."
220 - 2. False. Change "should not be" to "should be."
220 - 3. False. Change "primary roads" to "all access roads."
220 - 4. True.
220 - 5. True.
220 - 6. True.
220 - 7. False. Change "senior fire offical" to "pad safety officer."

221 - 1. True.
221 - 2. False. The point of attack on a natural cover fire cannot be made before the fire start. The point of attack must be based on a careful analysis of the (then) present and future conditions of the fire as determined by the terrain and the fuel and weather conditions.
221 - 3. True.
221 - 4. False. Limited equipment is but one of the many variables involved and should not be considered as the primary reason.
221 - 5. False. The best predisaster plans can be developed only when the military and civilian agencies coordinate and prepare one master plan.
221 - 6. False. Military disaster plans should be designed around the estimate made of each installation's target value.
221 - 7. True.
221 - 8. False. You should use only one set of symbols on all plans so that they will be easily read by all firefighters.
221 - 9. False. Those preplans for disasters and, in most cases, natural cover fires will be a part of the Base Disaster Plan and are not normally put on the AF Form 1028.

222 - 1. True.
222 - 2. True.
222 - 3. False. Change "to prevent" to "in the event of."
222 - 4. False. Change "response" to "recall."
222 - 5. True.
222 - 6. (1) d; g.
(2) a; b.
(3) e; f.
(4) c.

CHAPTER 5

223 - 1. The fire chief.
223 - 2. The alarm center operator.
223 - 3. The fire chief determines the equipment requirements, subject to the approval of the local CEM board. The alarm center equipment requirements are based on the requirements of the installation.
223 - 4. The reserved emergency line phone system must have a dual fire reporting capability.
223 - 5. The primary crash alarm.
223 - 6. The installed system alarm transmission system.
223 - 7. The public address facilities and sounding devices.
223 - 8. The fire crash/nontactical radio net.
223 - 9. The voice recorder.

224 - 1. Immediately after you receive the information.
224 - 2. The assistant fire chief on duty.
224 - 3. Those agencies needed to support the situation so that special request may be made and plans made.
224 - 4. By checking the operating instructions or from the assistant chief.

225 - 1. Attentiveness and knowledge of the system.
225 - 2. Inattentiveness could result in a missed call or signal.
225 - 3. To enable you to translate codes into necessary actions.
225 - 4. To insure that you issue the proper information to responding crews and make correct entries in the station log.
225 - 5. The station log.
225 - 6. Enter the necessary information on an AF Form 1271 and give the form to the individual at the first opportunity.

226 - 1. This information is necessary for offical reports of the incident.
226 - 2. The location.
226 - 3. By using a stern order such as "Don't hang up the phone."
226 - 4. You should make legible and meaningful abbreviations that you can rapidly and accurately translate.
226 - 5. So they will have some idea of what they face.
226 - 6. Provide the responding crews a clearer and better picture of what they will encounter when they arrive at the scene.
226 - 7. The responding crews will be better prepared to cope with the situation and attack the emergency in a way that will not further endanger the lives of those involved.
226 - 8. Such hazards as materials that will react dangerously to the heat of the fire or that are incompatible with water or other extinguishing agents.
226 - 9. So that these persons may be contacted for information that may be needed during investigations of the incident.
226 - 10. To note special circumstances about the emergency such as streets being blocked, a hydrant out in that area, etc.

227 - 1. Turn the bunkroom lights on.
227 - 2. To be sure that personnel are aware of the location and nature of the emergency.
227 - 3. Once all the responding vehicles are out of the station.
227 - 4. Turn on the bunkroom lights and open the stall doors.
227 - 5. The fire chief.

228 - 1. When the sounding system is used too often, for other than emergency uses, the crews tend to disregard it to some degree.
228 - 2. When excessive delays are encountered.
228 - 3. Other crews out of the station will know another crew is out, where they will be, and why they are out.

229 - 1. Fixed, mobile, and portable units.
229 - 2. The radios that are both sending and receiving sets.
229 - 3. NEVER.
229 - 4. AFR 92-1.
229 - 5. To alert all units to standby for an emergency transmission. 10-10-10.
229 - 6. a. 10-4.

b. 10-9.
c. 10-10.
d. 10-13.
e. 10-15.
f. 10-19.
229 - 7. BRAVO, OSCAR, UNIFORM, LIMA, TANGO, INDIA, ECHO, ROMEO.

230 - 1. Any information received that may influence an emergency response should be considered pertinent.
230 - 2. Unnecessary radio traffic could cause an important transmission to be cut out or misunderstood.
230 - 3. As soon as it is received.
230 - 4. Treat it as pertinent, and relay it.

231 - 1. Y for Yes; a, b, d, and e.
N for No; c (this information should be put on an AF Form 1271).
231 - 2. a and d.
231 - 3. The senior fire officer in charge at the close of each work shift.

232 - 1. School.
232 - 2. Island.
232 - 3. Highway, railroad.
232 - 4. 8635.
232 - 5. This area is a woods covered hill. A train track and dirt road pass through parts of it, as does a stream.
232 - 6. Right and up.
232 - 7. 1,000
232 - 8. 15
232 - 9. Radial distance lines.

233 - 1. By their applicable hazard symbols.
233 - 2. The flight line ramp and airfield map.
233 - 3. On the water-distribution system utility drawings.
233 - 4. From the ledgend, scale, or schedule section on that drawing.
233 - 5. Most of your maintenance will be to see to it that the information is kept current and the items themselves are in good shape.

CHAPTER 6

234 - 1. Forest fires.
234 - 2. The future water supply and timber supply and with the loss of hunting, fishing, and recreational facilities, to say nothing of the loss of human life which may occur.
234 - 3. Man; his carelessness.
234 - 4. Prompt discovery.
234 - 5. Training and organization.
234 - 6. The perimeter or fireline.
234 - 7. Along the fireline.
234 - 8. Ground fires, surface fires, crown fires, and spot fires.
234 - 9. Ground.
234 - 10. Surface.
234 - 11. Crown.
234 - 12. Spot fire.
234 - 13. Head.
234 - 14. Tail.
234 - 15. All portions of the fireline between the tail and the various heads and those slower burning areas between the heads are called flanks.
234 - 16. Downwind.

235 - 1. Powered handtools can be used to fell trees, clear brush, and eliminate heavy brush growth in an effort to confine fire spread.
235 - 2. To store water.
235 - 3. 60 gpm through 1½-inch hose at 100 psi.
235 - 4. Rubberlined canvas-covered (for durability) and unlined linen (for lightness).
235 - 5. A fire broom.
235 - 6. Mattock.
235 - 7. 5 gallons.
235 - 8.
  a. You should have considered (1) lack of roads, (2) inaccessibility to heavy equipment, (3) limited bridge capacities, (4) abundant water supplies, and (5) natural firebreaks created by the streams.
  b. You should advise the community (1) that there is a possibility of fast moving crown and surface fires; (2) that firefighting vehicles would be of little value, except on the perimeter of the wooded areas; (3) that portable pumps, backpacks, and handtools will be most advantageous for combating a fire; and (4) that natural firebreaks should be improved upon as a fire line of defense against conflagrations.

236 - 1. Sectional.
236 - 2. One-lick.
236 - 3. The intensity of the fire and the type, height, and denseness of the natural cover.
236 - 4. Flanks; tail; head.
236 - 5. The direct method of control.
236 - 6. Fog.
236 - 7. Indirect.
236 - 8. 44 feet (the firebreak should be at least twice as wide as the surrounding natural cover).
236 - 9. Backfire.
236 - 10. The location of all personnel and equipment, wind direction and velocity, and any natural and/or artificial firebreaks in the area.
236 - 11. Lie face down on the ground and cover your head with your coat or shirt (wetted if possible).
236 - 12. You will consider (1) your location in relation to the fire, (2) wind direction, and (3) logical fire travel. As a safety precaution, you will advise your crew not to approach the fire from within the canyon if any other way can be found to stop the fire.
236 - 13. When the entire fireline is under control and all progress of fire heads is stopped.
236 - 14. Move large logs so that they will not roll downhill and trench other burning objects deeply enough to catch and hold any falling embers.

237 - 1. Miscellaneous fires are those fires that do not readily fall under the category of aircraft, structural, missile, weapon, or natural cover fires.
237 - 2. Electrical shock.
237 - 3. The rim may explode from any wheel.
237 - 4. The location of the fire and material burning.
237 - 5. By becoming familiar with each type of equipment used.
237 - 6. Anytime you find it necessary to walk over any part of the dump or landfill area itself.
237 - 7. Storage.

CHAPTER 7

238 - 1. Bi-propellant.
238 - 2. Toxicity, fire and explosion.
238 - 3. They are ingestion, absorption, and inhalation.

238 - 4. The objectionable odor, resembling mustard or chlorine.
238 - 5. Two.
238 - 6. National Fire Code.
238 - 7. A dike high enough to hold 10 percent more than the tank capacity.

239 - 1. Minus 297° F.
239 - 2. The production of very low temperatures.
239 - 3. The formation of explosive gels when spills occur.
239 - 4. Water spray.
239 - 5. Cutting off the flow of oxygen or fuel.
239 - 6. They are ineffective.
239 - 7. Evaporation.

240 - 1. Nitrogen tetroxide and nitrogen dioxide.
240 - 2. The health hazard.
240 - 3. For handling nitrogen tetroxide during transfer or storage.
240 - 4. They will ignite spontaneously.
240 - 5. It will hasten its evaporation.

241 - 1. Inhibited red fuming nitric acid.
241 - 2. Aniline and other amines.
241 - 3. When there is danger of splashing or spraying.
241 - 4. The flare type.
241 - 5. By stopping all flow of acids and fuel.
241 - 6. By diluting with large quantities of water.

242 - 1. Furfuryl alcohol.
242 - 2. They will ignite spontaneously.
242 - 3. Good housekeeping.
242 - 4. Methyl, ethyl, and isopropyl.
242 - 5. Class B fires using water fog, carbon dioxide and/or alcohol-compatible type foam.
242 - 6. Because considerable dilution is needed before combustion ceases.

243 - 1. The vapors are irritating.
243 - 2. Relatively high pressures may build up.
243 - 3. Moderate.
243 - 4. Because the heat generated can easily generate considerable fumes.
243 - 5. As a fertilizer.

244 - 1. They readily take up and retain moisture.
244 - 2. UDMH.
244 - 3. 150 gallons of water (75 gallons for hydrazing).
244 - 4. vapor.
244 - 5. It cools as well as dilutes the fuel.
244 - 6. Water.

245 - 1. For identification purposes.
245 - 2. The aromatic content.
245 - 3. Spill fires, tank or pool fires, and flowing fuel fires.
245 - 4. To avoid the formation of gels.
245 - 5. By being absorbed in sand or dirt or flushed down with water.

246 - 1. Low temperature (-40° F.) makes them brittle, while high temperature (+140° F.) makes them soft.
246 - 2. Cylindrical.
246 - 3. The internal perforation is made in a variety of geometric shapes.
246 - 4. By being sealed within the rocket motor.
246 - 5. As explosives.
246 - 6. To propel missiles.
246 - 7. Composite and colloidal.
246 - 8. Nitrocellulose and nitroglycerine.
246 - 9. To build specific characteristics into the solid propellants.
246 - 10. Quantity-distance tables.
246 - 11. Their relative ease of ignition.
246 - 12. Because it has not been completely proven that all solid propellants are insensitive to such forces as shock, impact, or friction for ignition, nor that they will not detonate.

247 - 1. Electrical and chemical.
247 - 2. The chemical units.
247 - 3. Because of their extremely high reactivity.
247 - 4. Trimethyl and triethyl aluminum.
247 - 5. High boiling hydrocarbons.

248 - 1. Both contain fuels, oxidizers, starting devices, electrical systems and people.
248 - 2. In general, only the amount of propellant needed for each test or launch.
248 - 3. The testing usually involves new propellants, new missiles, and new techniques. (The layouts are very similiar.
248 - 4. Sites that are above ground where they are vulnerable to enemy attack.
248 - 5. Wet stands are constructed so that large quantities of water flow over the flame deflector to cool it during firing; dry stands do not.
248 - 6. To prevent the depletion of the water supply for firefighting.

249 - 1. The size and nature of the operation.
249 - 2. To ensure sufficient water supplies for firefighting.
249 - 3. Water spray nozzles ring the silo at various levels.
249 - 4. They may be cut off in the event of a major spill.

250 - 1. At operational sites involving a limited number of missile launch stands and at hardened sites where the missiles are stored or launched from underground.
250 - 2. Fixed systems.
250 - 3. In service rooms where fuel is involved.
250 - 4. The hazard of flashback.
250 - 5. Periodic training of operating personnel.
250 - 6. During the more hazardous standby operations and in firefighting operations where there is a possibility of oxygen deficiency or toxic fumes.

251 - 1. You should conduct simulated drills to see if the preplans fully cover the anticipated emergencies properly.
251 - 2. The exact nature of the relationship between the fire department and other support services is established.
251 - 3. The periodic reviews let you correct deficiencies in such operations and allow you to reassess the need for the standbys based on actual experience.
251 - 4. The most effective use of personnel and equipment.
251 - 5. The plans must be flexible enough to permit the senior fire officer to adapt the plans to fit a particular situation.
251 - 6. So that they will not be cut off from excape or otherwise immobilized in the event of an accident.
251 - 7. So that you can follow the entire emergency operation and judge when withdrawal or a change in tactics is required.
251 - 8. Emergency personnel and equipment are withdrawn to fallback areas.

251 - 9. During static test; because the test are conducted on wet stands.

251 - 10. When fuel and oxidizer tanks on liquid-propelled vehicles become involved.

251 - 11. Because of the danger of explosion or detonation; also, the capability of fixed water systems on or about the pad is greater than the capability of the fire department for controlling this type of fire.

251 - 12. After the missile safety officer calls in the fire organization and you are at the site.

251 - 13. After a major accident when the full capabilities of the department have been utilized.

CHAPTER 8

252 - 1. Foot-pounds.

252 - 2. The normal runout on concrete or asphalt overruns.

252 - 3. They will reduce the energy capacity by approximately 20 percent.

252 - 4. In the applicable technical orders.

252 - 5. By cutting the electrical wires on the nose strut.

252 - 6. Chain type.

253 - 1. By having the cable pull out two heavy anchor chains.

253 - 2. Two steel stanchions (and intermediate stanchions).

253 - 3. In the control tower.

253 - 4. To release the pendant at the proper instant during an arrestment.

253 - 5. 900 feet. The first 90 feet being single chain; next 180 feet being double (double is approximately 360 feet of single) chain layout is each side of runway.

253 - 6. To support the webbing at the center of the runway.

253 - 7. To operate the air compressors.

253 - 8. Manually.

253 - 9. They allow the pendant to yield as aircraft run over it.

254 - 1. Either direction (takeoff or landing).

254 - 2. 55,000,000 (55×10^6).

254 - 3. 950 feet.

254 - 4. 3½ minutes.

254 - 5. The lifter straps flip the pendant cable up.

254 - 6. The friction brake.

254 - 7. The main hydraulic pump.

254 - 8. Approximately 65,000 pounds.

254 - 9. A tape connector tire casing.

254 - 10. Shuttle valve.

254 - 11. You rewind the tapes on the storage reels and pretension the pendant.

254 - 12. Manually. Never use the rewind motor to align the pin and holes.

254 - 13. On the follower.

255 - 1. In the same manner used for the permanently installed rotary friction barrier; i.e., by correlating the readings to the telltale pressure gage, or tachometer, with applicable TO chart.

255 - 2. It has four brake assemblies to absorb the energy of arrestment. The permanently installed model has only two brake assemblies to absorb the energy of arrestment.

255 - 3.
- a. The barrier is air transportable and can be installed in approximately 8 hours.
- b. It has two arresting engines installed on opposite sides of the runway.
- c. The reel and shaft assembly of each arresting engine consists of one tape reel, two rotary friction type brakes, a gasoline engine for rewinding the tape, an instrument panel, a battery, and a fuel tank.
- d. The four brakes give it a higher energy-absorbing capacity, (65,000,000 foot-pounds as compared to 55,000,000 foot-pounds).

255 - 4.
- a. The switch matting senses aircraft speed and the aircraft location on the runway relative to the center line.
- b. The computer computes aircraft speed and opens air valves directly in front of the aircraft at the precise time to engage the aircraft.
- c. The quick-opening high-pressure air valves open to allow the high-pressure compressed air to propel the pendant upward to engage the aircraft.

255 - 5. To provide equal braking action on each reel. It must be synchronized at the initial installation, when a component part affecting synchronization has been replaced, and at time intervals specified by the TO (usually 6 months).

255 - 6.
- a. The cam is manually set to the 60° position.
- b. The engine throttle is set to drive the pump at 780 rpm.
- c. Pump output pressure is adjusted to 800 psig.

256 - 1. Two turbine type energy absorbers, the runway edge sheaves, and the runway pendant.

256 - 2. A mixture of water and glycol.

256 - 3. The solution is usable in most ambient temperatures, it lubricates the turbine bearings, and its viscosity increases the barrier's energy capacity.

256 - 4. An electric motor or an internal combustion engine.

256 - 5. A capstan on the turbine assembly.

256 - 6. The operator swings them away from the reels.

257 - 1. Chain type barriers consist principally of a main control box containing air compressors, air accumulators, battery power supply, and associated controls. The auxiliary control box is located on the opposite side of the runway from the main control box. The battery powered air compressors supply high-pressure air to the accumulators, two in the main control box and one in the auxiliary control box. The accumulators supply low-pressure air (by use of a regulator on the discharge side) to four-way control valves, one located on each side of the runway. These valves control the raising and lowering of the main stanchions. Electrical control switches for operating the valves are located in the main control box and the control tower.

257 - 2. A leak in the system or back through the compressor(s) is indicated.

257 - 3. Deicing fluid.

257 - 4. One revolution of one strand around the core of a wire rope.

257 - 5. Eighteen months.

257 - 6. When the runway pendant is held less than 2 inches above the runway surface.

257 - 7. You should be careful to avoid spirals in the cable. Spirals may lead to kinks.

257 - 8. After each engagement.

258 - 1. Four or more broken wires (in all strands) are

within the length of one rope lay; it has been in service over 18 months; or a sharp kink cannot be removed readily be pretensioning the cable.

258 - 2. By flushing with water under pressure.

258 - 3. Solution leaks in the piping, water pump, and various connections. Also, see that there is enough solution and that it is clean.

258 - 4. By measuring the extrusion of the adjuster pin.

258 - 5. Six months.

258 - 6. It must be removed from the reel, and turned end-for-end, and reinstalled after 15 to 18 arrestments.

258 - 7. From the runway edge sheave to the pendant end.

258 - 8.
  a. Reset the cam zero index so that it is on the cam follower.
  b. Check the tape stack height to see that it meets the minimum prescribed by the TO.

258 - 9. Immediate replacement of the purchase tapes.

258 - 10.
  a. Reduce clutch accumulator pressure to 50 psig.
  b. Position one tape connector to the desired final location on the runway.
  c. Drive a vehicle onto the tape adjacent to the tape connector.
  d. Press rewind "reverse" button to rewind tape.
  e. Release button when other tape connector is in proper final rewind position.
  f. Remove vehicle from tape.
  g. Recharge clutch accumulator with compressed air to 800 psig (+200-0).
  h. Pretension pendant in the usual manner.

258 - 11. Daily.

258 - 12. Charge it with compressed air.

258 - 13. During the semiannual inspection.

258 - 14. 220 or 440 volts, 3-phase, 50- or 60-cycle electrical power.

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STOP - **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.** **2. USE NUMBER 2 PENCIL ONLY.**

57150 02 24

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

GENERAL SUBJECTS FOR FIRE PROTECTION

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (200) The vapors from a flammable material with a vapor density of 0.3 would be expected to
   - a. collect in low places.
   - b. mix with air and be found at all levels.
   - c. dissipate completely and not collect at any level.
   - d. collect in high places.

2. (200) The type of fuel and percent of oxygen present will determine the
   - a. flashpoint.
   - b. ignition temperature.
   - c. magnitude of a fire.
   - d. intensity of a fire.

3. (201) Usually, the safest and best method of extinguishing a compressed gas fire is
   - a. cooling.
   - b. chemical reaction.
   - c. smothering.
   - d. separation.

4. (202) Carbon dioxide is a desirable extinguishing agent because
   - a. it is very effective on Class A and D fires and has limited success on Class C fires.
   - b. it is noncombustible and nonreactive with most substances and provides its own pressure for discharge.
   - c. being a gas, it can penetrate and spread to all parts of the fire, cooling the material to below its flashpoint.
   - d. of all of the above.

5. (202) A fire involving an energized electrical motor and oil-soaked rags would most successfully be fought with
   - a. dry powder.
   - b. regular dry chemical.
   - c. water.
   - d. multipurpose dry chemical.

6. (202) The agent to use in a total flood system in a computer room is
   - a. dry powder.
   - b. Halon 1301.
   - c. dry chemical.
   - d. carbon dioxide.

7. (202) The aqueous film forming foam (AFFF) used by the Air Force is designed to be applied to hydrocarbon fuel fires at a mixture of what ratio of water to AFFF concentrate?
   - a. 12 gallons of water; 3 gallons AFFF.
   - b. 47 gallons of water; 3 gallons AFFF.
   - c. 60 gallons of water; 6 gallons AFFF.
   - d. 100 gallons of water; 6 gallons AFFF.

8. (203) Which of the following would be a gas?
   - a. A fluid with a pressure of 14.7 psig.
   - b. A fluid with a pressure of 22.0 psia.
   - c. A fluid with a pressure of 24.0 psia.
   - d. A fluid with a pressure of 37.6 psig.

9. (204) When installed in an approved manner over wood studs, which one of the following materials will protect one face of the combustible material?

a. Gypsum board.
b. Ordinary plywood.
c. Celluloid-type material.
d. Animal material insulation.

10. (205) Explosives which present a mass fire hazard, comparable to Quantity Distance Class 2, are assigned to which one of the following Class Divisions?

a. 1.1.
b. 1.2.
c. 1.4.
d. 1.3.

11. (205) Class Division 1.4 explosives include which of the following hazards?

a. Nonmass detonating, fragment producing explosions.
b. Moderate fire but no blast.
c. Mass fire and blast.
d. Mass detonating.

12. (206) Which one of the following items is not included in storage Compatibility Group C?

a. Bulk propellants.
b. Propelling charges.
c. Devices containing propellant with or without means of ignition.
d. Liquid propellants.

13. (207) A self-contained breathing apparatus cannot be used when combating fires where the chemical hazard symbol has a rim and figure in

a. red.
b. white.
c. black.
d. yellow.

14. (207) Photoflash cartridges and blasting caps are stored under fire symbol

a. 1.
b. 2.
c. 3.
d. 4.

15. (207) The storage area of harassing agents are marked with a chemical hazard symbol having the rim and figure of what color?

a. Red.
b. Blue.
c. White.
d. Yellow.

16. (208) Chemical munitions are classified in all of the following ways except

a. effect.
b. purpose.
c. tactical use.
d. method of deployment.

17. (209) Except in the downwind direction, alpha contamination should not be expected to extend more than how many feet from the site of an accident or fire involving a nuclear weapon?

a. 300.
b. 1,000.
c. 2,000.
d. 500.

18. (210) The major hazard of biological munitions is the

a. presence of an explosive device.
b. inability of personnel to detect them.
c. speed with which they destroy all life forms.
d. fact that the weapons may break or be blown open, without any accompanying fire

19. (211) EXPLOSIVES A and EXPLOSIVES B placards have the symbol and inscription in black, and the background is

a. red.
b. green.
c. yellow.
d. orange.

20. (211) Placards showing seven red stripes and six white stripes are used to denote the presence of which of the following?

a. Flammable solids.
b. Posion and poison gas.
c. Oxygen and oxidizers.
d. Corrosives and organic peroxide.

21. (211) Which one of the following lists of placards has a symbol which is common to all placards in that list?

a. EXPLOSIVES A, EXPLOSIVES B, and DANGEROUS.
b. CHLORINE, POISON, and POISON GAS.
c. COMBUSTIBLE, OXYGEN, and OXIDIZER.
d. FLAMMABLE, FLAMMABLE SOLID, and FLAMMABLE SOLID W.

22. (212) Radioactive contamination of personnel and equipment is checked at the

a. "ground zero."
b. permanent third echelon decontamination locations.
c. station after all vehicles have been put back in service.
d. checkpoint set up by the disaster control command post.

23. (212) The principal piece of equipment used in second echelon decontamination is the

a. 3-gallon apparatus.
b. 5-gallon back pack.
c. 1,500-gallon water distributor.
d. crash truck that is not premixed.

24. (213) A 15-pound capacity carbon dioxide extinguisher weighs 34 1/4 pounds empty. What is the minimum acceptable weight of this extinguisher before recharging is necessary?

a. 32 3/4 pounds.
b. 47 3/4 pounds.
c. 49 1/4 pounds.
d. 53 1/2 pounds.

25. (214) The types of extinguisher that should undergo a hydrostatic test every 12 years is the

a. cartridge-operated water.
b. cartridge-operated dry powder.
c. dry chemical with stainless steel case.
d. carbon dioxide not made to DOT specifications.

26. (214) Which one of the following conditions would not warrant the destruction of an extinguisher?

a. The extinguisher has been burned in a fire.
b. Pitting exists due to corrosion.
c. The cylinder threads are cross threaded by accident.
d. The hose is weather cracked and fails under pressure.

27. (215) Which one of the following parts or assemblies would you normally make the most extensive repairs on?

a. Hoses.
b. Gages.
c. Heads.
d. Nozzles.

28. (215) The type of extinguisher that can not be inverted to bleed off pressure prior to disassembly is the

a. dry-powder.
b. dry-chemical.
c. carbon dioxide.
d. pressurized water.

29. (216) When recharging a carbon dioxide cylinder, the cylinder being recharged should be inverted to

a. force the transfer pump to pump oxygen.
b. keep it cooler and to permit faster filling of the cylinder.
c. keep the supply hose within the 3-foot maximum length.
d. allow the cylinder to warm faster and equalize the pressure within the cylinder.

30. (216) When recharging a carbon dioxide cylinder using the bypass filling unit, the transfer of carbon dioxide depends on

a. a gasoline- or electrical-driven pump.
b. the supply cylinder being in an upright position with its head above the the extinguisher head.
c. a difference of temperature and coresponding difference in pressure between two cylinders.
d. the weight of the supply cylinder and the proper operation of the pumping equipment.

31. (216) Before recharging the dry-chemical extinguisher, you must first

a. dump out the old agent.
b. remove the top and fill with proper type agent.
c. invert the extinguisher and bleed off any remaining pressure.
d. remove the used expelling cartridge and replace it with a new one.

32. (217) When computing back pressure, what is the average height per floor in Air Force buildings?

a. 8.35.
b. 11.5.
c. 12.
d. 14.7.

33. (217) Which of the following formulas would you use to compute rate of discharge (gpm)?

a. $27.9 \times D^2 \times \sqrt{P}$.
b. $29.7 \times D \times \sqrt{P^2}$.
c. $29.7 \times P \times \sqrt{D}$.
d. $29.7 \times D^2 \times \sqrt{P}$.

34. (217) What is the rate of discharge (gpm) from a 2 1/2-inch open butt flowing at 49 psi?

a. 1098.
b. 1169.
c. 1220.
d. 1299.

35. (217) 400 gpm are flowing through a 2 1/2-inch hose. What is the friction loss per 100 feet of hose?

a. 36 psi.
b. 34 psi.
c. 40 psi.
d. 144 psi.

36. (217) 75 gpm are flowing through a 2 1/2-inch hose. What is the friction loss per 100 feet of hose?

a. 1.5.
b. 1.875.
c. 10.
d. 25.

37. (217) The height to which water can be drafted is governed primarily by the

a. source of the water.
b. atmospheric pressure.
c. temperature of the water.
d. position of the changeover valve.

38. (217) A truck that weighs 11,000 pounds empty can carry how many gallons of water without endangering a bridge that has a 15-ton load limit?

a. 479.
b. 1569.
c. 2275.
d. 3592.

39. (218) When making a prefire plan on a building, you should make the entries on

a. AF Form 1028.
b. AF Form 1027.
c. AF Form 1034.
d. AF Form 1071.

40. (219) Aircraft characteristics that are to be included in the prepared AF Form 1028 are found in

a. AFR 92-1.
b. AFR 127-101.
c. TO 00-105E-9.
d. all of the above.

41. (219) Prefire plans are not required for

a. mission-assigned aircraft.
b. missile sites and rocket pads.
c. facilities equipped sprinkler or deluge systems.
d. transient aircraft landing at least three times in 7 consecutive months.

42. (221) The most difficult plans to develop will be the

a. building prefire plans.
b. aircraft prefire plans.
c. domestic disaster preplans.
d. missile site prefire plans.

43. (222) What response priority is designated for buildings in direct support of the mission, the loss of which would seriously impair mission capability?

a. 1.
b. 2.
c. 3.
d. 4.

44. (223) When handicapped personnel are assigned duties as communications operators, they must be certified by the

a. fire chief.
b. base medical officer.
c. assistant fire chief for operations.
d. NCOIC of the alarm and communications center.

45. (223) If, as an alarm center operator, you are the first to receive information about a crash, the fastest way to notify the control tower, medical center, and base operations would be to

a. activate the primary crash network.
b. dial 117.
c. activate the secondary crash network.
d. use the administrative telephone network.

46. (224) The support activities should be notified of an impending emergency

a. as soon as the vehicles are dispatched.
b. before the assistant chief is notified.
c. right after you hang up the crash phone.
d. at the earliest possible time.

47. (225) While receiving a fire alarm call, the information should be noted

a. in the station log.
b. on Air Force Form 1271.
c. on a recording board.
d. on a piece of scrap paper.

48. (226) The crews should know the nature of the emergency to which they are responding so that they

a. will know which hydrant to catch.
b. can insure the correct building is reached.
c. will have some idea of what they will face upon arrival.
d. can advise the base commander of the plan of action.

49. (227) The first thing you should do when informing personnel of an emergency during sleeping hours is to

a. open all the stall doors.
b. activate the sounding devices.
c. turn on the bunkroom lights.
d. activate the public address system.

50. (227) Which of the following steps should normally be omitted when informing personnel of an emergency during daylight duty hours?

a. Opening the stall doors.
b. Activating the sounding devices.
c. Activating the public address system.
d. Repeating the information after the trucks have left the station.

51. (228) When crews take an excessive amount of time in responding to a nonemergency, the alarm center operator should

a. activate the sounding system.
b. report the crew chief to the assistant fire chief.
c. counsel the crew chief when the crew returns to the station.
d. tell the driver to respond with the crew chief and note the incident in the log book.

52. (229) Whenever a vehicle is away from the station, its radio should be monitored by someone designated by the

a. fire chief.
b. crew chief.
c. alarm center operator.
d. assistant fire chief on duty.

53. (230) Unnecessary radio traffic may result in

a. misunderstood or cutout transmissions.
b. premature failure of transceivers.
c. too much information transmitted to the crews.
d. removal of radio equipment from vehicles for at least 90 days.

54. (231) Which one of the following statements is a red-ink entry in a station log?

    a. The rescue truck had a flat tire at 4th and "A" streets.
    b. The crossman crew used the P-8 for drafting practice.
    c. The P-4 ran over the mechanic's foot and crushed it.
    d. Three acres of grass burned between the runway and taxiway.

55. (231) The log book at a subordinate station will be reviewed and signed by the

    a. fire chief during his daily inspection.
    b. station captain going off duty that day.
    c. assistant fire chief prior to relieving the shift.
    d. senior fire officer in charge at that station.

56. (232) The coordinates that are the most valid for use on an on-base grid map are

    a. B 2 B.
    b. 1 D 14.
    c. H 6.2 D 1.
    d. 1 3c D4.

57. (232) Which one of the following series of numbers is an invalid grid coordinate point?

    a. 2174.
    b. 350269.
    c. 73420.
    d. 82011740.

58. (232) Using grid coordinate, 513901, the digits that would identify the horizontal line on a map are

    a. 5 and 9.
    b. 513.
    c. 901.
    d. cannot be determined.

59. (232) Using grid coordinate 513901, the first series of digits to be used in finding the grid location is

    a. 513.
    b. 39.
    c. 901.
    d. 5319.

60. (233) The fuel/power emergency shutoff valves for a particular section of the installation are found on the

    a. installation layout map.
    b. fire-alarm location map.
    c. POL, gas, and electricity distribution drawings.
    d. flight line and airfield ramp map.

61. (233) The update on the utility charts should be checked for currency at least

    a. weekly.
    b. monthly.
    c. semiannually.
    d. annually.

62. (234) What is the type of natural cover fire that burns at or below ground in humus, peat, and other organic materials?

    a. Spot.
    b. Duff.
    c. Crown.
    d. Surface.

63. (234) A natural cover fire in which the heat is intense but short-lived because of the quick-burning characteristics of the fuels is known as a

a. duff fire.
b. crown fire.
c. ground fire.
d. surface fire.

64. (234) The most feared of all natural cover fires is the

a. crown fire.
b. spot fire.
c. ground fire.
d. surface fire.

65. (234) The upwind, or windward, portion of a natural cover fire is the

a. tail.
b. head.
c. flank.
d. fireline.

66. (234) All other factors being equal, that part of a natural cover fire which burns fastest through draws or canyons is known as the

a. shoulder.
b. flank.
c. tail.
d. head.

67. (235) The handtool considered indispensable when combating fires in thick vegetation and bush is the

a. fire axe.
b. fire broom.
c. undercutter.
d. brush hook.

68. (236) The fastest and easiest method of combating a running natural cover fire is to

a. use a sectional method.
b. use the one-lick method.
c. make a firebreak.
d. start a backfire.

69. (236) The direct method of fire control is very effective against natural cover fires but can be used only

a. against very small grass fires.
b. in areas that have heavy rainfall.
c. on fires that are moderately hot.
d. against fires running uphill or in draws.

70. (236) Whenever possible, a backfire should be set so that it will

a. meet the main fire head in a canyon or draw.
b. move downhill to meet the main fire head in the valley.
c. move uphill and reach the ridge at almost the same time and the head of the original fire.
d. burn with the head of the advancing fire until firebreak or natural barrier is reached.

71. (237) Which of the following fires would be a miscellaneous fire?

a. Drapes in the dayroom of the fire station burning.
b. Engine burning on an F-4 on the trim-pad.
c. Brakes overheating on a 40-foot trailer, burning the tires off.
d. Six hundred square feet of grass burning between the taxiway and runway.

72. (238) The dike around storage tanks for liquid propellants must hold how much more than the storage containers?

a. 10 percent.
b. 5 percent.
c. 25 percent.
d. 50 percent.

73. (239) If ignition occurs prior to, or concurrently with, the mixing of liquid oxygen and a fuel, the type of combustion that will occur is a

a. minor detonation.
b. flare-type fire.
c. violent explosion.
d. very low temperature fire.

74. (240) The main problem in fighting fires involving nitrogen tetroxide is

a. avoiding the toxic vapors given off.
b. avoiding the use of water.
c. disposing of the spill.
d. avoiding its mixture with air.

75. (241) The type of acid most frequently used at missile sites is

a. sulfuric acid.
b. hydrochloric acid.
c. inhibited red fuming nitric acid.
d. inhibited white foaming nitric acid.

76. (242) The alcohol that is hypergolic with fuming nitric acid is

a. ethyl.
b. methyl.
c. furfuryl.
d. isopropyl.

77. (243) Liquid ammonia spills should be diluted with

a. acid.
b. water.
c. sodium dichromate.
d. high-boiling hydrocarbons.

78. (244) The two hydrazines used as missile fuels are hygroscopic which means that they

a. readily take up and maintain moisture.
b. produce very low temperature.
c. ignite upon contact with any component without aid.
d. readily take up and dissipate moisture.

79. (244) Of the two hydrazines used as missile fuels, which is the more highly volatile?

a. UDMH.
b. Heptane.
c. Toluene.
d. Hydrazine.

80. (245) Normally, in a closed container, the vapors of hydrocarbon fuels are too rich to ignite except

a. RP-1.
b. JP-4.
c. TP-5.
d. UDMH.

81. (245) The three types of fires that may be encountered where hydrocarbon fuels are used are

a. spill, tank or pool, and flash.
b. tank or pool, flowing, and crown.
c. flowing, spill, and duff.
d. tank or pool, flowing, and spill.

82. (246) The rate of total gas evolution from solid propellants is controlled by the

a. thickness of the rocket motor case.
b. atmospheric pressure at which they burn.
c. type of ignition system employed in the missile.
d. geometric shape of the internal perforations.

83. (246) A solid propellant containing both nitrocellulose and nitroglycerine is referred to as

a. monopropellant.
b. composite propellant.
c. colloidal propellant.
d. double-based propellant.

84. (247) Fires involving the pyrophoric alkyl-almuninum compounds should not be fought with

a. water fog.
b. dry sand.
c. carbon dioxide.
d. special dry powders.

85. (248) The major quantities of propellant materials for use at test and launch complexes are stored in the

a. fallback area.
b. underground silos.
c. bulk storage area.
d. ready storage area.

86. (249) The number of gallons of water required per minute for flame bucket cooling alone is

a. 5,000 to 10,000.
b. 12,500 to 17,500.
c. 20,000 to 30,000.
d. at least 500,000.

87. (249) What size hose is used to preconnect hose reels at test and launch facilities?

a. 1 inch.
b. 1 1/4 inches.
c. 1 1/2 inches.
d. 2 1/2 inches

88. (250) Provisions are made for automatic carbon dioxide flooding systems in what areas?

a. In areas where missiles are fueled or defueled in a horizontal position.
b. In areas where missiles are fueled or defueled in a vertical position.
c. In service rooms adjacent to or under the launch or test pad.
d. In a removal shelter where the missiles are stored in a horizontal position.

89. (251) During launch operations, emergency personnel and equipment are withdrawn to

a. the blockhouse.
b. the fallback areas.
c. the normal standby positions.
d. an area at least 5,000 feet upwind of the launch site.

90. (251) After a test or launch, who indicates when and which of the emergency services will be called into the area?

a. Fire chief.
b. Senior fire officer.
c. Launch officer.
d. Missile safety officer.

91. (252) What effect will sod overruns have on the energy-absorbing capacity of an aircraft arresting barrier?

a. Will have no effect.
b. Will increase it by approximately 30 percent.
c. Will decrease it by approximately 45 percent.
d. Will cause the aircraft to stop twice as fast.

92. (253) AC power is normally used on the chain type barrier to

a. charge batteries.
b. operate air compressors.
c. operate electric motors.
d. operate air compressors and four-way control valves.

93. (253) The part of the chain type barrier that is engaged by the aircraft nosewheel is the

a. pendant tape.
b. purchase cable.
c. main stanchions.
d. webbing assembly.

94. (253) The action which causes the aircraft to slow after engaging a chain type arresting barrier is the

a. dragging of chains.
b. compression of water in a tube.
c. braking system from a modified aircraft.
d. use of energy through the dissipation of heat.

95. (253) You would pretension the pendant of the chain type barrier by

a. using the pull lift.
b. using a 1 1/2-ton vehicle.
c. releasing pretension springs.
d. using the power-operated winch.

96. (254) When used as an interconnect engaging system, the webbing assembly pendant connects to the standard runway pendant by means of

a. a J-hook eye link.
b. an intermediate pendant.
c. a nylon rope and shear pin.
d. the two pendants which do not interconnect.

97. (254) In a rotary friction type barrier system, the telltale hydraulic pressure gage and tachometer are used to

a. determine tape replacement.
b. aid in pretensioning the pendant.
c. indicate aircraft engaging speed and weight.
d. indicate unequal runout of tapes from the storage reels.

98. (254) Hydraulic pressure to operate the rotary friction brakes is supplied by the

a. reel-driven pump.
b. engine-driven pump.
c. electric motor-driven pump.
d. pneumatic pressure of the accumulator.

99. (254) The purpose of the disc clutch on the rotary friction type barrier is to

a. pretension the pendant following arrestment.
b. lock the two reels and common shaft together.
c. help absorb some of the energy during arrestment.
d. allow freewheeling of the tape reels during rewind.

100. (254) The pendant of the rotary friction type barrier is supported above the runway surface by

a. rubber discs.
b. runway edge sheaves.
c. pretensioning force.
d. intermediate stanchions.

101. (254) The part of the rotary friction type barrier that is engaged by the aircraft during arrestment is the

a. purchase cable.
b. purchase tape.
c. pendant.
d. chain.

102. (254) During arrestment with a rotary friction type barrier, hydraulic pressure is controlled by the

a. speed of the pump.
b. reel-driven cam and control valve.
c. spring-loaded pressure regulated valve.
d. variable orifice in series with pump output.

103. (254) Excessive twisting of the nylon purchase tape on a rotary friction type barrier may be eliminated by

a. use of a tire casing.
b. replacing pendant support discs.
c. end-for-end switching of the tapes.
d. repairing the runway edge sheave(s).

104. (254) In a rotary friction barrier system, the brake accumulator fluid may be replenished by the use of the

a. hand-operated pump.
b. main hydraulic pump.
c. clutch shuttle valve.
d. portable hand-operated pump.

105. (255) What is the rewind time for the portable expeditionary type barrier?

a. 2 minutes.
b. 3 minutes.
c. 4 seconds.
d. 5 seconds.

106. (255) With the expeditionary barrier, the cam is manually set at 60°, the pump is driven at 780 rpm, and the hydraulic pressure is adjusted to 800 psig for the purpose of

a. rewinding the tapes.
b. pretensioning the pendant.
c. testing brake effectiveness.
d. synchronizing arresting engines.

107. (256) On the turbine type arresting barrier, the lead-off sheave is mounted

a. by the edge of the runway.
b. on the turbine assembly base.
c. above the capstan at the operator's console.
d. on the right side of the capstan.

108. (256) What is used to apply pressure to the purchase tape as it is being wound on the tape storage reel during the retraction cycle on the turbine type arresting assembly?

a. Runway edge sheaves.
b. Lead-off sheave assembly.
c. Tight-wrap roller assembly.
d. Backstop clutch capstan in the power train.

109. (256) What is the total gallon capacity of the cooling tanks for a turbine type arresting barrier?

a. 200 gallons.
b. 250 gallons.
c. 500 gallons.
d. 1,000 gallons.

110. (256) The cooling tanks for the turbine type arresting barrier contain a mixture of

a. water and detergent.
b. 40 percent water and 60 percent glycol.
c. 40 percent glycol and 60 percent water.
d. 50 percent water and 50 percent glycern.

111. (257) The term "one rope lay" means

a. a 10-foot section of wire rope.
b. a 15-foot section of wire rope.
c. one complete revolution of a strand around a wire rope.
d. two complete revolutions of a strand around a wire rope.

112. (257) The portions of a cable that must be lubricated are

a. all kinked areas.
b. areas which are corroded.
c. all exposed areas of cable.
d. ends of the cable at tape connections.

113. (257) The purpose of the main stanchions on the chain type barrier is to

a. support the entire webbing.
b. maintain tension on the cable.
c. support the webbing at the sides of the runway.
d. provide quick release of webbing when engagement occurs.

114. (257) If the pendant is not properly supported (less than 2 inches above the runway surface), you should

a. replace the pendant.
b. replace the rubber discs.
c. increase the pendant pretension.
d. replace the pendant pretensioning springs.

115. (257) The maintenance performed most often in the main control box of the chain type barrier is that required by the

a. purchase tape.
b. storage batteries.
c. cable connections.
d. brake drums and shoes.

116. (257) The hard-operated winch used to pretension the webbing on the chain type barrier is located

a. on the takeup reel.
b. in the control tower.
c. on each main stanchion.
d. on each intermediate stanchion.

117. (257) The purpose of the hinge arrangement at the base of each intermediate stanchion on the chain type barrier is to

a. maintain tension on the webbing.
b. maintain aircraft travel in a straight line.
c. permit aircraft tailhooks to connect the cable.
d. allow the stanchions to yield to the impact of an aircraft.

118. (257) Upon aircraft engagement, the actuator straps on the chain type barrier

a. disassemble.
b. stabilize aircraft movements.
c. provide quick positioning of webbing.
d. provide the necessary webbing tension.

119. (258) If the purchase tape carries too much sand and dirt into the sheave assembly during rewind, the

a. tape and sheave will bind in the cover assembly.
b. sand and dirt will accumulate in the sand trap.
c. sheave assembly is not affected by sand and dirt.
d. sand and dirt is prevented from entering by the brush assembly.

120. (258) If the water pump packing in a water/glycol solution system leaks more than an occasional drip, you should

a. replace the pump.
b. repack the pump packing.
c. take no action since this is to be expected.
d. make note and repair it during next scheduled maintenance.

121. (258) After each engagement and rewind of a rotary friction type barrier, what should be the proper psig reading, ± 10, for the brake accumulator aircharge?

a. 155.
b. 175.
c. 195.
d. 205.

122. (258) You would determine when to replace the disc brakes on a rotary friction type barrier by

a. measuring the thickness of brake disc linings.
b. measuring the projection of the adjuster pin.
c. measuring the volume of fluid required to energize the brakes.
d. checking the amount of tape runout for arresting a specified aircraft at a certain engaging speed.

123. (258) To distribute the wear equally over the entire length of the tape, you should

a. crop the tape at 6-month intervals.
b. lubricate the runway edge sheaves daily.
c. remove tape from reel and turn end-for-end at the specified time intervals.
d. coat the exposed portion of the tape with the prescribed silicon compound.

124. (258) How many volts are required to operate the rewind motor of the permanently installed rotary friction type barrier?

a. 12 or 24 volts.
b. 50 or 60 volts.
c. 110 or 210 volts.
d. 220 or 440 volts.

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CDC 57150

FIRE PROTECTION SPECIALIST

(AFSC 57150)

Volume 3

Fire Engineering and Investigation

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

YOU HAVE NOW completed Volumes 1 and 2 of this CDC. We want to encourage you to complete the course. In the past two volumes, you gained general knowledge about fire protection and gained some information on specific equipment or conditions.

In Volume 3 you will gain more needed knowledge to further broaden your concept of the fire-protection career field. In this volume we present information on building construction and design, fire detection and suppression systems, water supply and distribution, fire hazards, fire prevention training and public relations, and fire investigation.

Code numbers appearing on figures are for preparing agency identification only.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TT6OX, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercises, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 33 hours (11 points).

Material in this volume is technically accurate, adequate, and current as July 1979.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Building Construction and Design

THE PRINCIPLES of fire protection engineering must be adhered to by the engineer at the drawing board in the planning and design stage. These principles must carry through in the construction, maintenance, alteration, and operation of the facility. The separation of areas, spacing of buildings, selection of firesafe materials, and installation of fire protection systems and devices must all conform to the standards of safety.

The Air Force objective is to obtain structures consistent with those constructed under good commercial practice. The design for facilities will follow sound planning principles. Attention will be placed on scale, balance of elements, simple functional layouts, low first cost and low maintenance cost over the life expectancy period. Emphasized must be the selection of good current materials, construction details, components, equipment, structure, mechanical and electrical systems, methods of construction, and firesafe design.

Engineering practices and recognized fire protection principles must be correlated with the size, type, use, materials, occupancy hazards, and total cost of the facility. Fire protection standards must be met completely. There must be no cheating for economy or for expediency. Water supply and extinguisher requirements must also be met.

1-1. Building Design

The appearance of facilities should reflect the dignity and high standards of the Air Force. Design should be an expression of professional good taste. There should be a logical compromise between unimaginative stereotyping and imaginative overdesign. There should be no exotic or unusual configurations.

400. Given a list of statements concerning building design, identify those which are correct. If a statement is invalid, correct it.

The architectural and engineering design of facilities must be in accordance with the actual requirements of the project. Particular attention will be given to the building configuration, story heights, structural system, selection of interior and exterior finishes, and the extent and type of services and equipment.

Locations of individual structures should be in accord with proposed development, as shown on the installation master plan. When selecting a site, give consideration to the availability of existing main utility lines.

During the preparation of plans and specifications, the recognized fire protection and fire prevention practices will be followed by qualified fire protection engineers. These practices must be consistent with the size, nature, intended use, material, personnel and occupancy hazards, importance, and strategic value of the structure. Let's take a quick look at some of these fire protection and prevention practices.

Building Code Requirements. Building codes set forth rules for safety in the construction of buildings to the extent which can be applied as standard in all Air Force construction. The code should be recognized as reflecting minimum standards consistent with reasonable safety. Of course it does not necessarily provide complete safety or ideal conditions. Building codes vary in their fire-resistance requirements in accordance with the occupancy classification.

Intended Occupancy and Use. A building design is based upon the occupancy of the individual structure, considering both the combustibility of the contents and the human factors of occupancy. Buildings such as hospitals or airmen dormitories, for example, call for greater fire safety than do warehouses—which, it is assumed, are occupied by a few people able to leave quickly in case of fire. Large places of assembly, where crowds may generate panic hazards, call for a higher degree of protection than do types of occupancy where buildings are less populated. Buildings with *contents* of high combustibility call for a greater degree of fire resistance in the *structure*.

Life Safety. The most important factor in designing a building for life safety is the provision of adequate exits. Thus, upon the notification of fire, occupants can leave the building in the least possible time through exits free from fire, heat, and smoke. Panic in a burning building may be uncontrollable; but measures have been designed to help prevent panic—an example of this is exit signs. Experience indicates that panic seldom develops in a burning building so long as the occupants are moving toward exits which they can see within a reasonable distance and which have no obstructions in the path of travel. The life safety factor is affected by many building designs and features—designs and features that prevent, reduce, or retard the spread of fire. Some of these are fire stops, fire walls, and fire doors. These and other features are discussed later.

Fixed Fire Protection Systems. Fixed fire protection systems will be installed in accordance with sound economical and engineering practices. These systems insure the maximum degree of life safety—or maximum degree of property protection where the size, type of construction, occupancy, or other conditions create severe monetary or strategic fire-loss potential.

Spacing of Structures. Adequate separation of buildings and structures, which is necessary if we are to prevent the spread of fire from building to building or from area to area, is set forth in Air Force Manual 88-15.

Spacing requirements that restrict types of occupancies of specified areas on base have an important bearing upon fire safety. Consideration will be given to convenience, efficiency, and savings. We must combine compatible functions and facilities such as housing and dining areas, base supply and warehouses, and must make groupings of other similar buildings. When buildings have different occupancies and different types of construction are adjacent, maximum spacing requirements have to be observed.

Height Requirements. The height of buildings of masonry wall and wood construction is generally limited to a height assumed to be the maximum at which fire departments can operate effectively, working from the street level. The operational limit is usually three or four stories. Wood frame construction is generally given lower height limits. Fire-resistive buildings are commonly permitted without any height limit, on the theory that the structural integrity of the buildings will be maintained. Owing to the life hazard involved, it is a good practice to limit the height of structures that have an unusually high degree of combustibility.

Exercises (400):
If one of the following statements is correct, mark it True; if it is False, correct it.

____1. The architectural and engineering design of facilities will be based upon the development proposals shown on the installation master plan.

____2. Consideration should be given to the availability of existing main utility lines on or near the site when selecting a location for individual structures.

____3. During the review of plans and specifications for new facilities construction, recognized fire protection and prevention practices will be applied by qualified fire protection engineers.

____4. The fire-resistance requirements of the building codes vary in accordance with the necessity for providing complete safety.

____5. The human factors of occupancy and the combustibility of the contents are both considerations in the occupancy of individual structures.

___6. The provision of adequate exits is the most important factor in designing a building for life safety.

___7. Fixed fire protection systems will be provided in facilities to insure a minimum degree of life safety.

___8. Air Force Manual 88-13, *Air Force Design Manual—Criteria and Standards of Air Force Construction*, contains the criteria for adequate separation of buildings and structures—the separation which is necessary to preclude the spread of fire.

___9. It is a good practice to limit the height of structures that have an unusually high degree of combustibility—this limitation because of the conflagration hazard involved.

401. Given a list of statements concerning the fire retarding features in facilities, match each statement with the feature it best describes; and from a list of fire wall openings, match each fire wall opening with its class of opening and its required fire protection rating.

While a facility is still being designed, everything possible should be done to make the facility eventually fire safe. Fire-retarding features must be specified in the plans.

Fire Retarding Features. For the safety of personnel, important provisions in preventing the spread of fire (both vertically and horizontally in buildings) are fire stops, fire partitions, fire walls, and fire doors.

Fire stops. Where wood is used as a fire stop, it must be at least 2 inches thick. One other acceptable practice is to fill the concealed spaces with noncombustible material. Fire stops must be inspected during construction and, in general, are required in the following locations:

- The depth of wood joists and their support at the walls.
- The exterior and interior wood stud walls at ceiling and floor levels.
- In all-wood stud walls and partitions at a specified intermediate distance.
- In furred masonry walls and other furred spaces.
- Between stair stringers at least midway in each run; at top and bottom and between wood studs along and in line with the run of the stairs adjoining partitions.
- Around the top, bottom sides, and ends of sliding door pockets.
- Spaces between chimneys and wood framing. The space between the chimney and the wood floor or roof framing should not be filled except partly—as needed for fire stopping.
- Other locations, such as holes for pipes or ventilators which would afford passage for flame or hot gases.

Fire partitions. Fire partitions are installed in buildings to separate areas of hazardous occupancies from areas of ordinary or light-hazard occupancies and to resist the passage of fire from one area to another. Fire partitions must be constructed to have fire-resistance ratings of 1 or 2 hours. The degree of fire resistance will be governed by the type of building construction, the size of the hazardous area, and the severity of the fire hazard.

Fire walls. Fire walls are installed to prevent passage of fire from one building to another, or from one fire area of a building to another fire area. Besides meeting the fire-resistance rating, the fire wall must be structurally sound and may be a bearing wall if no combustible structural members are framed into the wall. Fire walls must have a parapet with a minimum height of 3 feet above the roof for all types of roof construction except roofs or top floor assemblies with a minimum fire-resistance rating of 2 hours. Fire wall returns or wing walls are required except where exterior walls of buildings are of concrete or of masonry construction. Fire walls will be bonded into exterior walls. Combustible eave construction should be interrupted by fire wall parapets corbelled out 2 feet beyond the building wall. Fire wall returns at exterior building walls will be 20 feet long of unbroken exterior concrete or masonry without windows, doors, or other openings, and without combustible cornices or roof overhangs. Where exterior platforms or canopies of combustible construction extend across the fire wall, those sections along the fire wall returns will be changed to noncombustible construction. Parapeted wing walls will extend at least 3 feet beyond the exterior walls of the building. Fire walls will extend across monitor construction and will have 3-foot wing walls on both sides of the monitor. The fire resistance rating of fire wall returns and wing walls may be reduced to 2 hours.

In addition to subdividing large storage areas, fire walls are used to separate large manufacturing and processing areas from storage spaces, and to separate large hazardous occupancies from less hazardous facilities. Fire walls are usually constructed of concrete, brick, concrete block, or structural tile block, but may be of other tested and approved noncombustible building materials such as mineral wood, rockwool, glass wool in blanket form, leaving about 1-inch depth at the exposed edges of the joints for caulking compound.

Openings. Fire wall openings are classed by their location and character within the wall. These classes are A, B, C, D, and E. NOTE: The classifications apply to the openings themselves and not to the fire doors as is often assumed.

Class A openings are in walls dividing a single building into fire areas or in walls separating buildings. A fire rating of 3 hours is required for doors protecting these openings.

Class B openings are passageways for stairs and elevators and require doors of a 1 or 1½ hour fire rating.

Class C openings are in room partitions and require doors offering protection for 3/4 hour.

Openings in exterior walls which are subject to severe fire exposure from outside the building are class D. Shutters or doors having a fire protection rating of 1½ hours are required for these openings.

Openings in exterior walls which are subject to light or moderate external fire exposure are class E openings. Windows, shutters, or doors for protection of these openings have a fire rating of 3/4 hour.

Fire doors and hardware. In fire walls and fire partitions, the number and size of openings should be kept to a minimum without interfering with building operations. All openings must have sliding, rolling, or hinged-typed automatic-closing fire doors and appropriate hardware. The fire doors and hardware will be of an approved type for the purpose intended. This approval must be made by a nationally recognized agency, competent to make such judgements. The approval must be evidenced by the attachment of the agency's seal or label to the equipment or appliance. The label or listing of the Underwriters' Laboratories or Factory Mutual Laboratories will be considered as evidence of acceptability. Fire door hardware and door installation will be in accordance with Standard No. 80 of the National Board of Fire Underwriters. All lintels, sills, and door frames will be of noncombustible materials for openings in fire walls. No openings will be provided through divisional fire walls in warehouses which are used for storage of flammable liquids, paints, dope, gases, or chemicals.

Exercises (401):

1. Match each of the statements in column B with the fire-retarding feature in column A that it best describes. Do so by writing the correct letter in the blank provided.

Column A

___1. Fire stops.
___2. Fire partitions.
___3. Fire walls.
___4. Openings.
___5. Fire doors and hardware.

Column B

a. These features are installed in buildings to separate areas of hazardous occupancies from areas of ordinary or light-hazard occupancies and to resist the passage of fire from one area to another.
b. A label or listing of the Underwriters' Laboratories or Factory Mutual Laboratories will be considered as evidence of acceptability and approval when these features have been included in a building.
c. These features are classed by their location and character within other features.
d. These features are installed to prevent the passage of fire from one building to another.
e. These features are generally required between stair stringers at least midway in each run.
f. The returns and wings of these features may be constructed with their fire resistance rating reduced to 2 hours.
g. When wood is used for these features, it must be at least 2 inches thick.

2. Match each of the fire wall openings in column B with its correct class in column A. Do so by writing the correct letter in the space provided. No item in column B may be used twice, and some items are not used.

Column A

___1. Class A.
___2. Class B.
___3. Class C.
___4. Class D.
___5. Class E.

Column B

a. Openings in walls dividing a single building into fire areas or separate buildings.

b. Openings in exterior walls which are subject to light or moderate external fire exposure.
c. Openings in room partitions.
d. Openings in fire resistive decks.
e. Openings in exterior walls which are subject to severe fire exposure from outside the building.
f. Openings are passageways for stairs and elevators.
g. Openings in walls in warehouses which are used for storage of flammable liquids, paints, dopes, gases, or chemicals.

3. Match each of the fire protection rating requirements in column B with the correct class of opening to be protected in column A—by writing the letter in the space provided.

Columun A	*Column B*
__1. Class A.	a. Windows or shutters with a 3/4-hour fire rating are required.
__2. Class B.	b. Doors with a fire rating of 3 hours are required.
__3. Class C.	c. Doors are required with a fire rating of 1 or 1½ hours.
__4. Class D.	d. Doors are required to offer protection for 3/4 hour.
__5. Class E.	e. Shutters or doors having a fire rating of 1½ hours are required.

1-2. Building Construction

402. Given a description of categories of construction, match each description with its correct category.

Categories of Construction. Air Force buildings and structures are categorized according to their life expectancy and their estimated maintenance requirements. These categories of construction are: permanent, semipermanent, temporary, and protective construction.

Permanent. Permanent construction is the result of quality and type of materials and equipment, coupled with the details and the construction methods that are appropriate for use in a building or facility intended to serve a specific purpose. The minimum life expectancy will be at least 25 years with normal maintenance.

Semipermanent. Buildings or facilities in this category are intended to serve a specific purpose for a limited period of time—less than 25 years and more than 5 years, with a higher-than-normal degree of maintenance.

Temporary. Temporary construction is that which provides minimum accommodations at low first cost, to serve a specific purpose for a short period of time, 5 years or less. The degree of maintenance is not a primary design consideration.

Protective construction. Protective construction may generally be defined as those passive measures which can be effected by construction or construction-related activities, to reduce or to nullify the effects of an attack upon an installation. This construction should also enhance the recoupability of such installations after attack.

Protective construction includes buildings or facilities which will (1) minimize effects of enemy weapons on the operations of our weapon systems, and (2) permit our weapon systems to return to operation quickly after damage from attack.

Exercise (402):

1. Match each of the descriptions listed in column B with its correct category of construction in column A. Make the match by writing the correct letter in the blank provided.

Column A	*Column B*
__1. Permanent.	a. The degree of maintenance for these facilities is not a primary design consideration.
__2. Semipermanent.	b. Facilities in this category may be defined as those passive measures which can be effected by construction to reduce or nullify the effects of an attack upon an installation.
__3. Temporary.	c. The minimum life expectancy of these facilities is at least 25 years with normal maintenance.
__4. Protective construction.	d. With a higher-than-normal degree of maintenance, these facilities should last more than 5 years but less than 25 years.
	e. These facilities are intended to serve a specific purpose for a limited period of time.
	f. These facilities are intended to provide minimum accommodations at low cost to serve a specific purpose.

403. State the types and classifications of construction, and complete statements concerning the types and classifications of construction.

Buildings and structures for Air Force construction are divided as to their relative degree of combustibility. There are two general types: Type N, noncombustible, and Type C, combustible. Each type is further divided into several specific classifications. These specific classifications denote relative degrees of fire resistivity—in accordance with recognized standards. The distinction between *noncombustibility* and *fire resistivity* must be recognized. These two measures-of-burning-potential are not synonymous. Both combustible and noncombustible construction may have varying degrees of relative fire resistivity, depending on their inherent qualities or their type of treatment. For additional information, refer to the National Building Code of the National Board of Fire Underwriters.

Type "N" Noncombustible Construction. This type of construction is one in which the structural framing, walls, partitions, and major components are wholly of noncombustible materials or assemblies. The three classifications of type "N" construction are:

- Fire resistive.
- Protected noncombustible (light fire resistive)
- Unprotected noncombustible.

Fire-resistive. This is construction in which the structural elements (such as walls, columns, piers, beams, trusses, floors, and roofs) are of noncombustible materials. With such quality and so protected, these structures will resist the maximum severity of fire expected within the structure—and will do so without collapse. Fire-resistive structures do not contribute to a fire following the ignition of combustible contents. A fire-resistive building has walls of masonry, reinforced concrete, or other noncombustible material having the required fire-resistance rating. Framing is of material with the required fire-resistance rating. Framing is usually of reinforced concrete or of structural iron or steel. It is protected with fire-resistive materials and thickness so as to conform to a definite period of fire resistance, as shown in figure 1-1. Engine test cells, vaults, some flammable and explosive materials storage areas, and hospitals are required to have this type of construction.

Some of the conventional methods of protection for the structural members are concrete, hollow clay tile, concrete blocks, tile, gypsum plaster, or cement plaster of a specified thickness. The need for protection of framing members can be appreciated from the

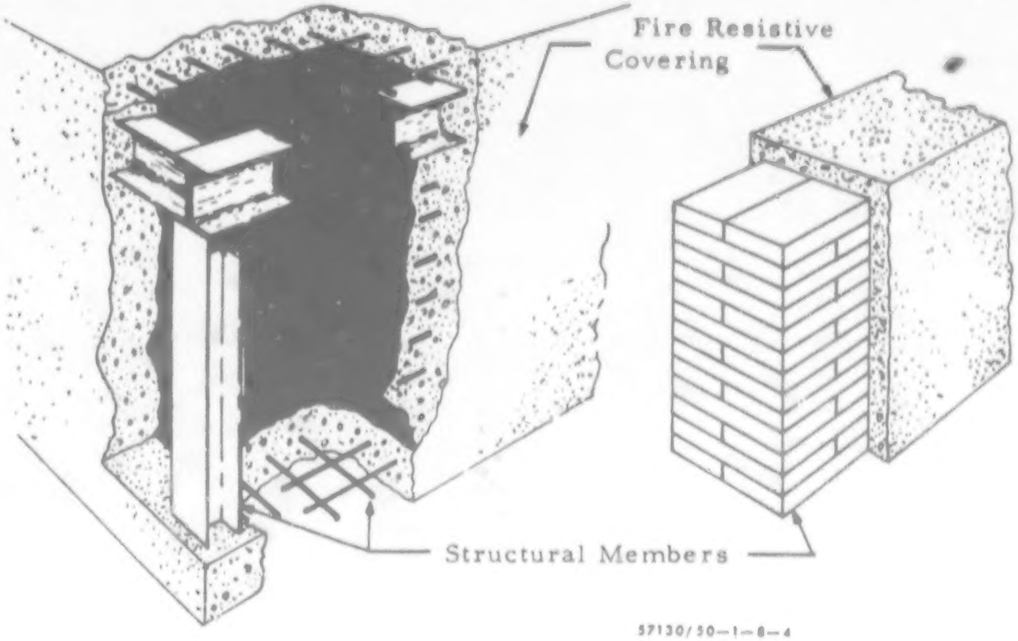


Figure 1-1. Protection of structural members.

following examples: a 100-foot length of steel, when heated to 1000° F., will expand 9½ inches. Floor surfacing and trim, while not necessarily required to be of noncombustible materials, should not contribute to the spread of fire.

Protected noncombustible (light fire resistive). This construction is that in which the structural members, including walls, partitions, columns, floor, and roof construction are of noncombustible materials having a lesser fire rating than does fire-resistive construction. Detention or confinement space, film storage, and one-story medical facilities, housing for bed-patients, all fall under this requirement.

Unprotected noncombustible. This is construction in which the structural elements are of noncombustible materials having no specific fire-resistive rating. Examples are structures built of noncombustible materials that fail to meet the requirement for fire-resistive construction of less than 1 hour rating.

Noncombustible materials as applied in building construction means steel, iron, brick, tile, concrete, slate, asbestos, wire-glass, cement, gypsum plaster or other materials that will not ignite nor burn when subjected to fire. Major administrative buildings, aircraft shops, BOQ and dormitories, club-type facilities, control towers, dry-cleaning plants, hangars, paint, oil and dope shops, POL pump houses, recreation facilities, and various other types of facility constructions are required to be of the type "N" unprotected noncombustible construction.

Type "C" Combustible Construction. A type "C" construction is one in which one or more of the major components (such as framing, floors, roof, exterior or interior walls) is combustible. The three classifications of this type are:

- Heavy timber.
- Ordinary construction.
- Wood framing construction.

Heavy timber. This is construction in which bearing walls and bearing and nonbearing portions of exterior walls are of masonry or reinforced concrete,—those walls having a minimum fire resistance of 2 hours and a stability under fire conditions. The columns, beams, and girders are of heavy timber, solid or laminated. Floor and roof construction of wood must have the thickness required. Members of wood nailed or bolted only are not considered laminated.

Dimensions for "heavy timber" may be columns not less than 8 inches in any dimension, beams and girders not less than 6 inches in width nor less than 10 inches in depth, floor or planks not less than 3 inches thick and covered with 1-inch flooring or of not less than 4 inches wide if laminated. The roof arches or trusses are of not less than 4 inches by 6 inches with roof decks of 2-inch planks—or, if laminated, planks not less than 3 inches.

Ordinary construction. In this construction the exterior walls are of masonry or reinforced concrete. Such a structure has a minimum fire resistance and stability of 2 hours under fire conditions. The structural members, including partitions, columns, floors, and the roof construction, are wholly or partly of wood or other combustible materials of smaller dimensions than required for heavy timber construction. This type of construction can be designated as protected ordinary construction when the roof, floor, and their supports, including stairways and inclosed floor opening partitions, have a 1-hour fire resistance.

Wood framing construction. This type of construction is defined as that in which the walls, partitions, floor, roof construction, and their supports are of wood or other combustible material. This type of building has a fire hazard similar to that of ordinary construction, except in regard to exposure and conflagration hazards. Large wood frame buildings are often characterized as "fire traps" and are subject to limitations such as height, area, and location.

Exercises (403).

Fill in the blanks in the following statements:

1. Buildings and structures for Air Force construction are divided into two general types as to their ______ ____ __ __________.
2. The two general classes into which Air Force construction is divided are ______, ______________ ; and _______ __ , ______.
3. The type of construction in which the structural framing, walls, partitions, and major components are wholly of noncombustible materials or assemblies is known as __________ __ , __________________.
4. The three classifications of type "N" construction are (1)________ - _________ ; (2)________ __________ (___ ________); and (3)__________ ___________.
5. The framing in fire-resistive buildings is usually of reinforced material protected with fire-resistive materials and of a thickness to________________________.
6. Floor surfacing and trim, in fire-resistive structures, while not necessarily required to be of noncombustible materials, should not __________________________.
7. Construction in which the structural members are of noncombustible materials with a_________________fire rating than fire-resistive construction is known as_______ _______ _______(_____ _____ - _________).

8. In unprotected noncombustible construction, the structural elements are of noncombustible materials without a ______ ______ - ______ rating.
9. Dormitories and recreation facilities are required to be of ______ ______ ______ ______ construction.
10. That type of construction design in which one or more of the major components is of combustible construction is considered to be ______ ______ construction.
11. There are ______ classifications of type "C" construction, which are ______ ______.
12. For construction to be considered as "heavy timber," the bearing and nonbearing portions of exterior walls must have a fire resistance of ______ ______ and ______ ______ ______ conditions.
13. In a structure considered as being "heavy timber," the beams and girders are not less than ______ in width nor less than ______ in depth, while the columns are not less than ______ ______ ______ ______.
14. Structures classified as "ordinary construction" have the exterior walls of ______ or ______ ______ with a minimum fire resistance and stability of ______ ______ ______ under fire conditions.
15. To be designated as "protected ordinary construction," an ordinary construction structure must have a ______ ______ ______ on the floors, roof, and their supports.
16. The type of construction in which the walls, partitions, floors, roof construction, and their supports are made of wood or other combustible materials is known as ______ ______ ______.

1-3. Plans, Drawings, and Specifications

The entire story of a construction project can be read in the lines, symbols, and notes of the blueprints for a job. It is necessary that you be able to interpret the plans, drawing, and specifications.

Earlier you learned that fire protection engineering is a part of the design process for all new construction. The same engineering practices must also be used, whenever possible, for all modifications or removation projects. The plans for these projects, as well as plans for self-help projects, must be reviewed and approved by fire protection personnel.

404. Given a list of statements concerning the types of plans and drawings with reading, interpretation and specifications, match the statement(s) with the term(s) that best relates to the statement.

Plans and Drawings. Architectural drawings are divided into two general classes: primary drawings, which consist of design sketches and drawings for display purposes; and working drawings (blueprints) which consist of views (flat surface line drawings) giving detailed information that the builders need during their construction of the building. The construction of a building is described by a set of drawings. These drawings give a thorough graphic description of each part of the operation. Usually a set of plans begins by showing the boundaries, contours, and outstanding features of the construction site. Succeeding drawings give instructions for erecting the foundation and superstructure and for the installation of lighting, heating, and plumbing. After that come the details of construction required to complete the building. Although these drawings are prepared in accordance with the general principles of right-angle projections (projections in which the projecting lines are perpendicular to the plane of projection), they differ from other drawings in certain practices.

The working drawings of a structure are presented in general and detail drawings. General drawings consist of plans and elevations; detail drawings are made up of sectional and detail views. Since it is the purpose of working drawings to be exact about shape and size, working drawings are generally scale-size projects. In some instances a proportional-size detail drawing may be included to show how parts look when they are assembled.

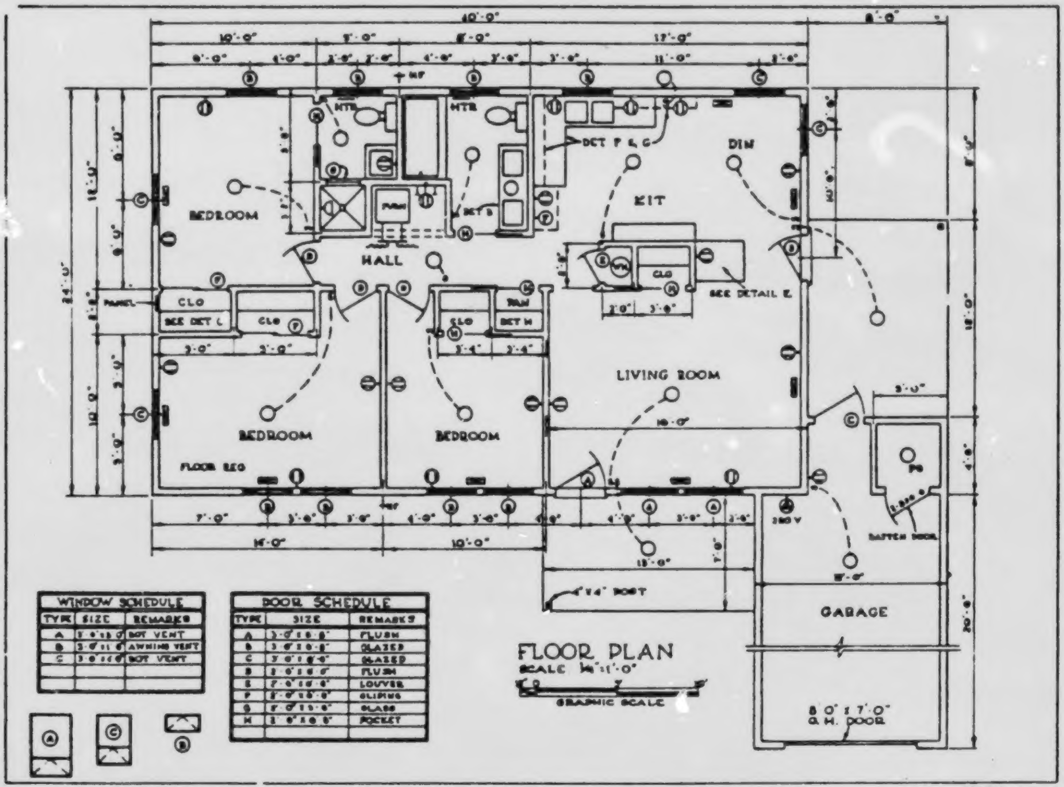
In architectural drawing, "plan" views are obtained by looking down on the object with a vertical line of sight. Plan views correspond to top views and involve only horizontal dimensions of length and width. Any view involving vertical dimensions is an "elevation." This could be a front view, side view, or any-other-elevation view. Different elevations are indicated as front, right, etc., or according to the direction from which the view is taken. There may or may not be on the drawing words which give the type and size of material used in the construction. This writing is called construction notes and is usually found at the bottom of the print. The graphic scale is usually located in the lower right corner of prints.

Because of the size of the object being represented, different scales are used for general and for detail drawings. In general, plan views and elevation views are drawn on separate sheets in order to make the view large enough for practical use. Detail views, drawn to a larger scale, furnish information not on general views. Detail views are strategically placed on the main views and on additional sheets as needed to give the worker a complete picture of the structure.

Floor plans. A floor plan, shown in figure 1-2, is a cross-sectional view of the building. This view is obtained by assuming that a building is cut in half horizontally, exposing every room in the building. If the building has more than one floor, a plan for each floor is drawn. The floor plan shows the outside shape of the building; the arrangement and size of rooms; the type of material; and the type, size, and location of doors and windows. In addition, it shows the heating, lighting, and plumbing fixtures.

Floor plans are usually drawn to small scales such as 1/4" = 1'-0", or 3/16" = 1'-0". This scale is shown at the bottom of figure 1-2. For this reason, conventional symbols are used to indicate fixtures and materials. For complex structures it may be necessary to supply separate utilities plans to show electrical, heating, and plumbing layouts.

A floor plan sheet may also contain details of construction, although these are generally presented on a separate sheet. When a detail drawing is furnished to show a particular construction, a reference is noted on the floor plan. Also shown on the floor plan are "schedules" for doors and windows. A schedule is a method of presenting notes and other construction data in the form of a table, as shown in the left lower corner of figure 1-2. A door schedule specifies the type, size, description, and location of each door, and a window schedule gives the same information for a window. By looking at the letter (B, for example) above or below the window symbol in figure 1-2, and then locating the same letter in the window schedule, you come up with the correct size and type of window—in this case 3'-0" x 1'-6" awning vent. The correct sizes and types of doors are located in the same manner. Through the use of standard plumbing and electrical symbols, it is easy to locate plumbing fixtures, hot and cold water lines, electrical wall and ceiling outlets, switches, types of wire, etc. Some of these symbols are illustrated and explained later in this chapter.


40'-0"
8'-0"
10'-0"
17'-0"
BEDROOM
HALL
KIT
DIN
DCT F & G
CLO
SEE DET L
SEE DETAIL E
LIVING ROOM
BEDROOM
BEDROOM
FLOOR REG
GARAGE
BATTEN DOOR
FLOOR PLAN
SCALE 1/4"=1'-0"
GRAPHIC SCALE
8'0" x 7'0"
O.H. DOOR
WINDOW SCHEDULE
TYPE
SIZE
REMARKS
A
B
C
BOT VENT
AWNING VENT
BOT VENT
DOOR SCHEDULE
TYPE
SIZE
REMARKS
A
B
C
D
E
F
G
H
FLUSH
GLAZED
GLAZED
FLUSH
LOUVER
SLIDING
GLASS
POCKET

37-70

Figure 1-2. Floor plan.

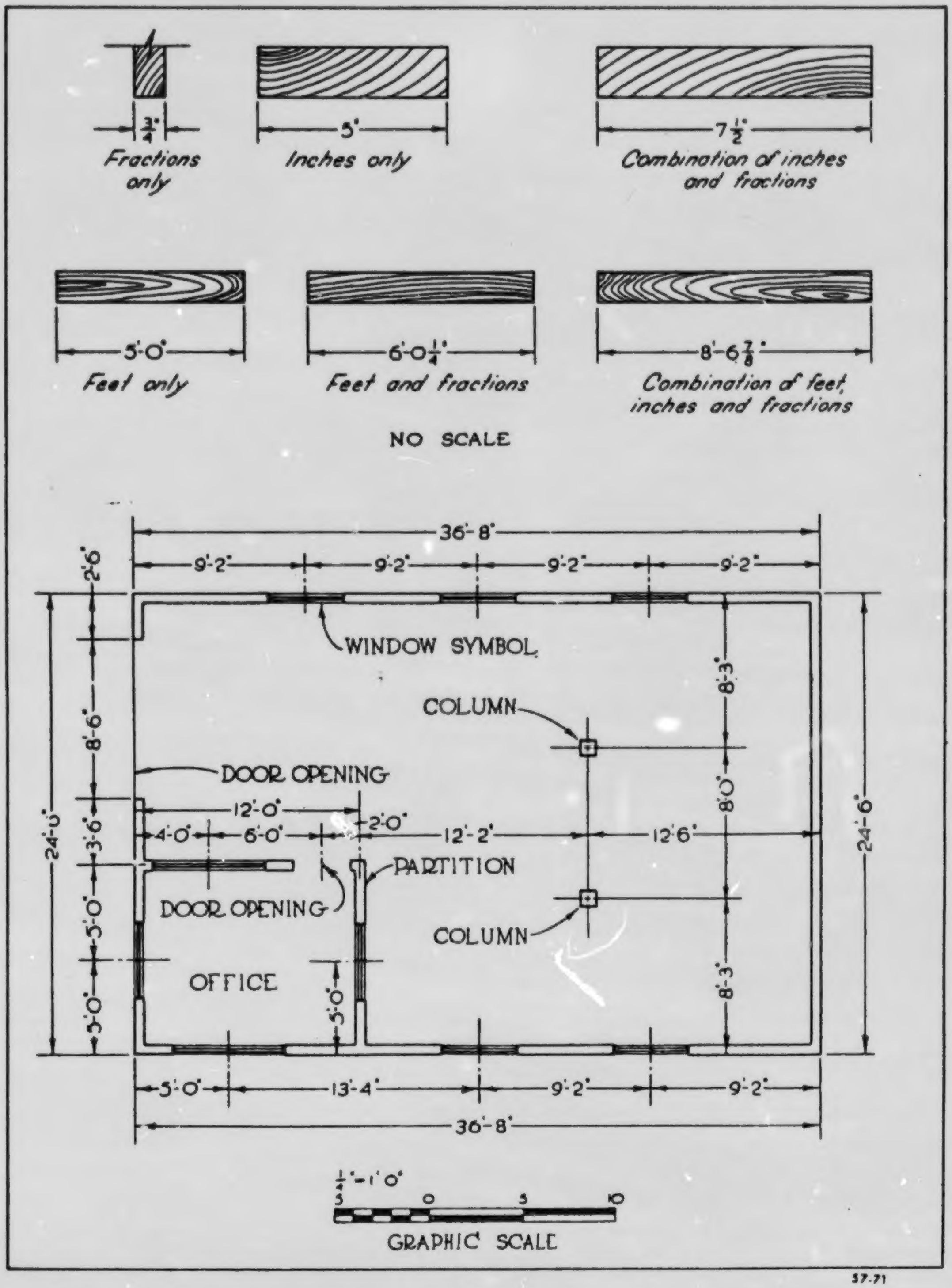

3/4"
Fractions only
5"
Inches only
7 1/2"
Combination of inches and fractions
5'-0"
Feet only
6'-0 1/4"
Feet and fractions
8'-6 7/8"
Combination of feet, inches and fractions
NO SCALE
36'-8"
9'-2"
9'-2"
9'-2"
9'-2"
2'-6"
WINDOW SYMBOL
8'-3"
COLUMN
8'-6"
DOOR OPENING
8'-0"
24'-0"
24'-6"
12'-0"
2'-0"
3'-6"
4'-0"
6'-0"
12'-2"
12'-6"
PARTITION
DOOR OPENING
COLUMN
5'-0"
OFFICE
5'-0"
8'-3"
5'-0"
5'-0"
13'-4"
9'-2"
9'-2"
36'-8"
1/4"=1'0"
5
0
5
10
GRAPHIC SCALE
57-71

Figure 1-3. Dimensioning.

Each person having anything to do with the construction of a building, runway, etc., has drawings, plans, specifications, and notes pertaining to his particular part of construction Since all information cannot be presented graphically, construction notes are extensively used. These notes are a vital part of every construction drawing, and they must be carefully worded. There are general notes pertaining to the entire set of plans, and there are local notes important only to certain sheets or certain parts of the drawing.

Drawing Details. The titles placed on drawings are very important. When they are placed on a drawing, they must be placed so as to clearly refer to the part, detail, or view which they identify. Titles for rooms must stand out clearly near the center of the area. Titles for detail views will be carefully placed for easy reading and must be correctly identified according to the reference system being used throughout the set of plans.

Dimensioning. Dimension lines are usually unbroken between extension lines, and dimensions are given in feet and inches. The numerals are placed slightly above or in the dimension line with the reading position from the bottom and right-hand edge of the sheet. The main requirement is that dimensions be clear, definite, and unmistakable. Figure 1-3 shows how fractions, inches, feet, and combinations of these are specified on plans or drawings.

Components of drawings. The blueprint method of reproduction has been so widely used that plans of all types are now quite often called blueprints. The blueprint is the builder's guide. It is a complete diagrammatic sketch, with dimensions, of a structure to be built and contains most of the information needed by the builder. All builders must know how to read blueprints and how to build by them. The blueprint, as used by the builder, is made up of different types of lines showing various views with a scale and legend.

Working lines. The lines which represent the edges of surfaces are somewhat heavier than the other lines on the drawing and are known as working lines. These lines may be straight or curved, depending upon the shape and view of the object.

Hidden lines. An outline of a part which is invisible in the particular view is known as a hidden line and is represented by a series of short dashes approximately 1/8 inch in length. The space between dashes is about equal to the length of the dash.

Center lines. Center lines indicate the center of an object. They are also used to show the center of holes or opening in objects and curved portions.

Extension lines. It is sometimes necessary to lengthen or extend working lines on a drawing. These lengthened lines are known as extension lines. The end of an extension line should never join the working line which it extends.

Dimension lines. Dimension lines are used to show the size of a structure or any structural part. They are light lines drawn between working lines or extension lines to show the distance between two points. Each end of the dimension line has an arrowhead to indicate the point where the measurement begins and ends. The points of the arrow should just touch the line where the measurement starts and stops. Numerals which give the exact distance between the arrow points are placed somewhere in the length of the dimension line. Sometimes working lines are too near each other so that we cannot place a dimension line between them. Then we place two dimension lines outside the working lines. The arrows point toward each other, and the numerals are placed outside one of the dimension lines.

Break lines. Two types of break lines are used. One kind indicates short breaks and the other indicates long breaks. The short break line is drawn freehand. A ruled line with occasional freehand zigzags is used for long breaks. Break lines indicate that an object continues without change in detail. Only a short portion of the entire object is represented when break lines are used.

Specifications. In the preceding paragraphs, you learned something about working drawings and how to read them. These drawings and prints would be worthless without the written notes and specifications that explain the types of materials and the different aspects of the job. So you can see the importance of construction notes and specifications.

On a drawing the written notes and explanations about materials or other items are called specifications. It is necessary to have these written notes in order to give complete information. For example, a symbol on a drawing may show that a building is to have wood siding. The carpenter must know how much of the siding is to be exposed to the weather. This information is given as a note on the drawing.

In addition to the notes on the drawing, a written set of specifications is included as a part of every complete set of plans or prints. These specifications are as important as the drawings. They describe all materials, and then give detailed instructions concerning the

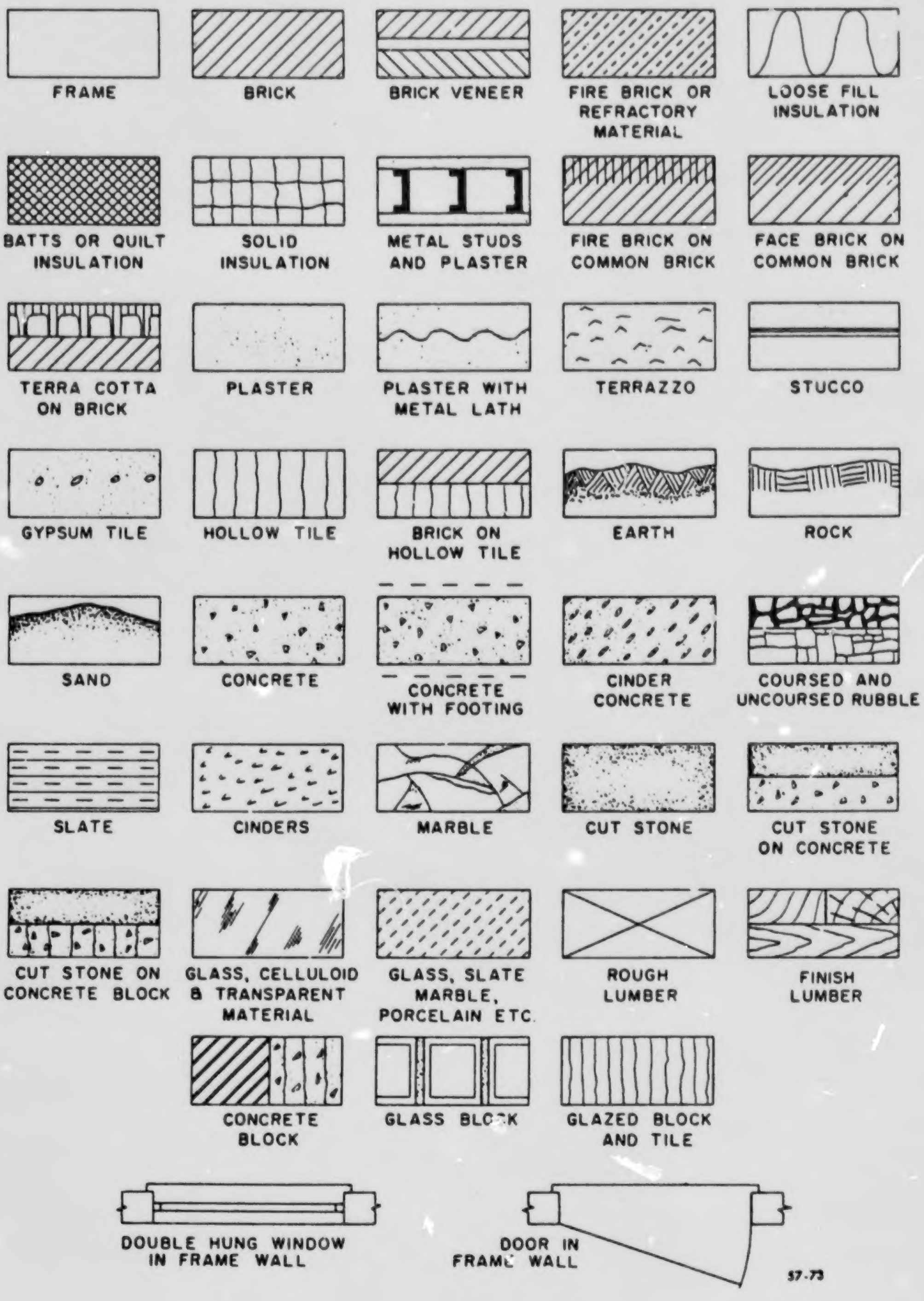

FRAME
BRICK
BRICK VENEER
FIRE BRICK OR REFRACTORY MATERIAL
LOOSE FILL INSULATION
BATTS OR QUILT INSULATION
SOLID INSULATION
METAL STUDS AND PLASTER
FIRE BRICK ON COMMON BRICK
FACE BRICK ON COMMON BRICK
TERRA COTTA ON BRICK
PLASTER
PLASTER WITH METAL LATH
TERRAZZO
STUCCO
GYPSUM TILE
HOLLOW TILE
BRICK ON HOLLOW TILE
EARTH
ROCK
SAND
CONCRETE
CONCRETE WITH FOOTING
CINDER CONCRETE
COURSED AND UNCOURSED RUBBLE
SLATE
CINDERS
MARBLE
CUT STONE
CUT STONE ON CONCRETE
CUT STONE ON CONCRETE BLOCK
GLASS, CELLULOID & TRANSPARENT MATERIAL
GLASS, SLATE MARBLE, PORCELAIN ETC.
ROUGH LUMBER
FINISH LUMBER
CONCRETE BLOCK
GLASS BLOCK
GLAZED BLOCK AND TILE
DOUBLE HUNG WINDOW IN FRAME WALL
DOOR IN FRAME WALL
57-73

Figure 1-4. Material symbols

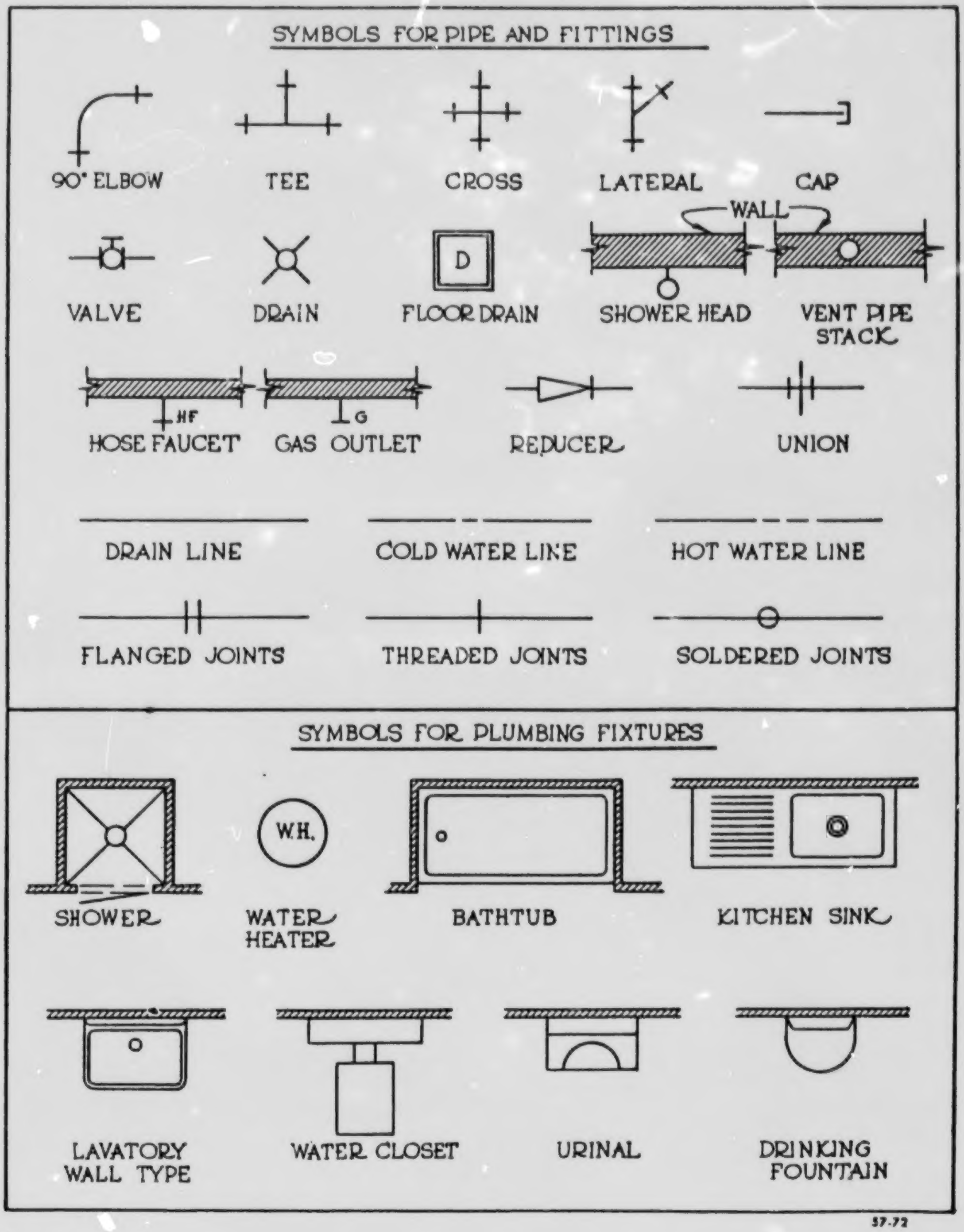
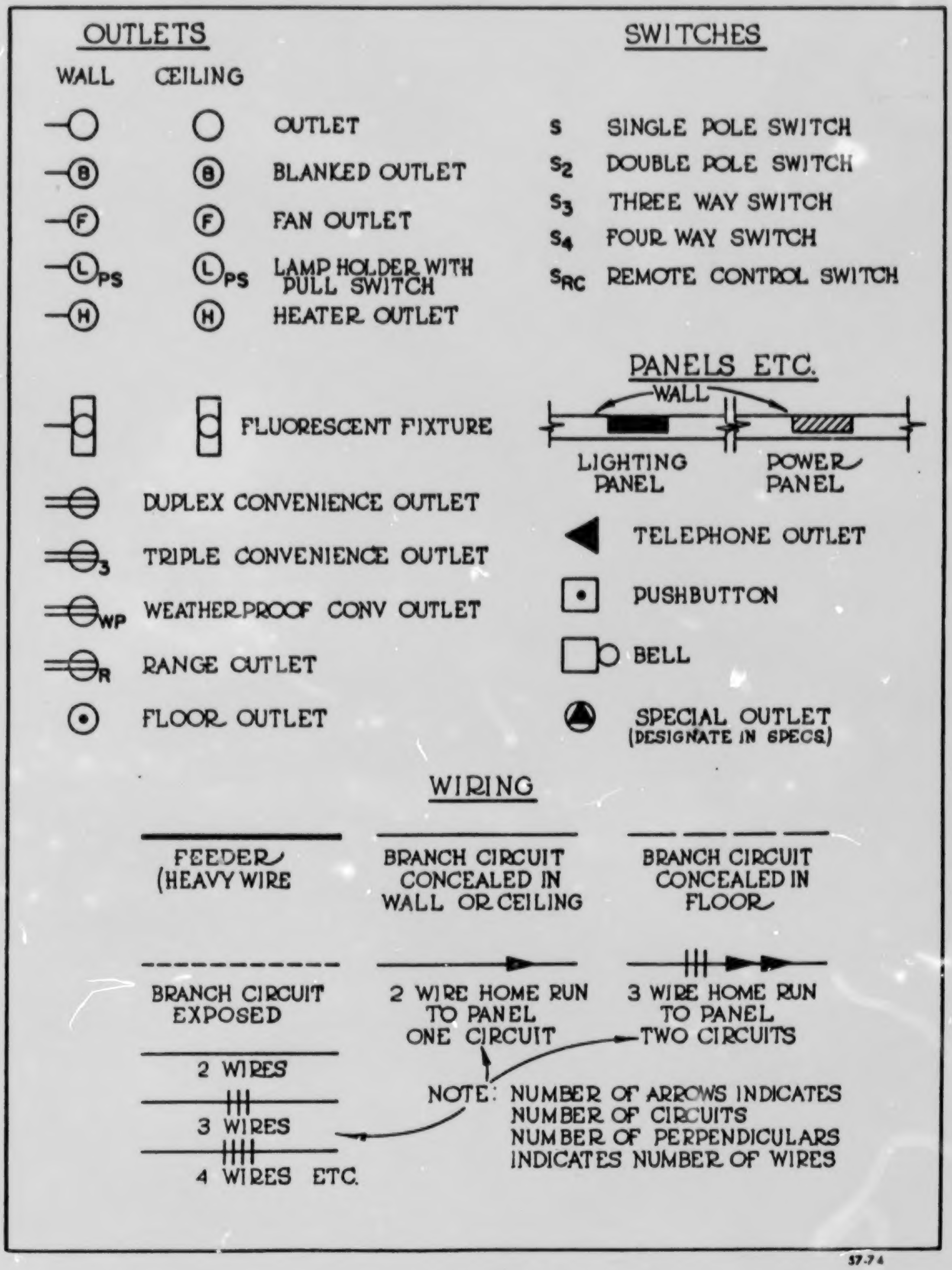

SYMBOLS FOR PIPE AND FITTINGS
90° ELBOW
TEE
CROSS
LATERAL
CAP
WALL
VALVE
DRAIN
D
FLOOR DRAIN
SHOWER HEAD
VENT PIPE STACK
HF
G
HOSE FAUCET
GAS OUTLET
REDUCER
UNION
DRAIN LINE
COLD WATER LINE
HOT WATER LINE
FLANGED JOINTS
THREADED JOINTS
SOLDERED JOINTS
SYMBOLS FOR PLUMBING FIXTURES
W.H.
SHOWER
WATER HEATER
BATHTUB
KITCHEN SINK
LAVATORY WALL TYPE
WATER CLOSET
URINAL
DRINKING FOUNTAIN
57-72

Figure 1-5. Plumbing symbols.


OUTLETS
WALL
CEILING
OUTLET
B
BLANKED OUTLET
F
FAN OUTLET
L PS
LAMP HOLDER WITH PULL SWITCH
H
HEATER OUTLET
FLUORESCENT FIXTURE
DUPLEX CONVENIENCE OUTLET
3
TRIPLE CONVENIENCE OUTLET
WP
WEATHERPROOF CONV OUTLET
R
RANGE OUTLET
FLOOR OUTLET
SWITCHES
S SINGLE POLE SWITCH
S2 DOUBLE POLE SWITCH
S3 THREE WAY SWITCH
S4 FOUR WAY SWITCH
SRC REMOTE CONTROL SWITCH
PANELS ETC.
WALL
LIGHTING PANEL
POWER PANEL
TELEPHONE OUTLET
PUSHBUTTON
BELL
SPECIAL OUTLET (DESIGNATE IN SPECS.)
WIRING
FEEDER (HEAVY WIRE
BRANCH CIRCUIT CONCEALED IN WALL OR CEILING
BRANCH CIRCUIT CONCEALED IN FLOOR
BRANCH CIRCUIT EXPOSED
2 WIRE HOME RUN TO PANEL ONE CIRCUIT
3 WIRE HOME RUN TO PANEL TWO CIRCUITS
2 WIRES
3 WIRES
4 WIRES ETC.
NOTE: NUMBER OF ARROWS INDICATES NUMBER OF CIRCUITS
NUMBER OF PERPENDICULARS INDICATES NUMBER OF WIRES

37-74

Figure 1-6. Electrical symbols.

building. The specifications must be studied as carefully as we study the drawings.

The specifications are usually made in separate divisions for each of the building trades, such as plumbing, painting, or carpentry. For example, the division pertaining to carpentry will indicate who will furnish and complete all carpentry work shown on the drawings or given in the specifications. This division will contain a list of work included as follows:

- All wood framing, including framing for all trades.
- All woodwork, trim jambs, doors, paneling, plywood, and interior millwork.
- All wood furring, nail strips, sleepers, blocking, grounds, wood bucks, wood studs, etc.
- Rough hardware (nails, spikes, bolts, etc.).
- Finish hardware.
- Cutting and fitting all woodwork in this division for work of all trades.
- All other carpentry work necessary to accomplish the particular job.

Each division of the specifications will contain specific information about the materials to be used on the job. For example, the material section of the carpentry division gives all information related to materials and methods of installation as listed below:

- The exact grade, species, size, and moisture content of wood to be used for various parts of the building.
- The spacing of various members, such as studs, rafters, joists, etc.
- The placing of studs, trimmers, or headers around all openings.
- The type of wood to be used for interior finish when this information is not indicated on the drawings.
- The erection of all members plumb, level, square, and true in accord with details.
- The use of fastening devices, such as nails, bolts, screws, toggles, etc.
- All other information necessary to assure that the materials used are of a certain standard and that the workmanship is acceptable.

In addition to the other information included in the specifications, a complete description of the building site should be included. A drawing showing how the building is to be placed on the specified plot of ground should be included in the plans.

Exercise (404):

1. Match each of the statements listed in column B with the term(s) in column A which best relates to the statement. Make the match by writing the correct letter in the blank provided. Each statement may be used only once.

Column A

___1. Construction notes.
___2. Dimension lines.
___3. Floor plans.
___4. Primary drawings.
___5. Specifications.
___6. Plan views.
___7. Elevation.
___8. Hidden lines.
___9. Dimensions.
___10. Working drawings.
___11. Views.
___12. Break lines.
___13. Detail drawings.
___14. Extension lines.
___15. Schedules.
___16. Detail views.
___17. Working lines.

Column B

a. These lines are represented by a series of short dashes about 1/8-inch long, and outline a part which is invisible in the particular drawing.
b. This is a cross-sectional view of the building.
c. The purpose of these drawings is to be exact about size and shape.
d. These views involve only horizontal dimensions of width and depth.
e. These lines are used to show the size of a structure or structural part.
f. These drawings are also known as blueprints.
g. These lines indicate that an object continues without change in detail and only a short portion of the entire object is represented when these lines are used.
h. These are usually made in separate divisions for each of the building trades.
i. These flat surface line drawings give detailed information necessary for actual construction of the building.
j. These are a vital part of every drawing and they must be worded carefully. They may be general in nature, pertaining to the entire set of plans, and/or local in nature, important only to certain sheets or parts of the drawing.
k. This term is used to describe any view involving vertical dimensions.
l. These lines represent the edges of surfaces and are somewhat heavier than the other lines on the drawing.
m. These views, drawn to a larger scale, furnish information not provided on general views.
n. These drawings consist

of design sketches and drawings for display purposes.

o. These are written notes and explanations about materials or other items that appear on a drawing.

p. These are placed slightly above or in the line with the reading position from the bottom and right-hand edge of the sheet and must be clear, definite, and unmistakable.

q. This is a method of presenting notes and other construction data in the form of a table.

r. These lines are used to lengthen working lines on a drawing.

s. These drawings are made up of sectional and detailed views.

405. Identify common symbols, terms, and abbreviations used in reading and interpreting plans, drawings, and specifications.

Symbols and Terms. Architectural symbols and terms are used to simplify the drawing. In order to read and understand blueprints, you must be able to interpret these symbols and terms. Some of the more common symbols are shown in figures 1-4, 1-5, and 1-6. See how many of them look like what they represent. Now read through the list of terms and definitions below.

BASEBOARD—A board placed around a room at floor level to form a finish between the floor and walls.

BASE SHOE—A molding placed around a room at floor level to form a finish between the floor and baseboard.

BEAM—A horizontal wood, steel, or concrete member used to provide support.

CANOPY—A projection over windows, doors, or porches to afford protection against weather.

CASEMENT—A window in which the sash opens upon hinges.

CASING—The wood trim on the vertical sides and top of an opening in a plastered wall.

CHAMFER—A beveled surface cut upon the corner of a piece of wood.

CORNICE—The horizontal molding around the top of a building just below the eaves.

DEADENING FELT—An asphalt impregnated felt used for waterproofing and weatherproofing buildings.

DORMER—A vertical window in a small gable rising from a sloping roof.

DRIP CAP—The projection above the exterior of a window or door to allow water to drain.

EAVES—The portion of the rafters which project from the lower edge of the roof.

FLASHING—Strips of sheet metal or composition roofing material used to waterproof roof intersections and other exposed places on the outside of the house.

FOOTING—The enlarged portion of concrete located in the bottom of foundation walls to spread the load and prevent settling.

GLAZING—The process of installing glass in window sashes.

HEADER—A short joist supporting tail beams and framed between trimming joists; the piece of stud or finish over an opening; or a lintel.

JAMB—The side pieces of a finished door or window opening.

KNEE WALL—The sloping portion of an interior wall which joins the vertical wall and ceiling—used where the wall is less than full room height because it meets the slope of the roof.

LATHS—Narrow strips to support plaster.

LATTICE—Crossed or interlaced wood, iron strips, or bars.

MULLION—The construction between the openings of two windows.

MUNTIN—The small, wooden dividing strips which separate panes or lights of windows.

PURLIN—A timber supporting several rafters at one or more points.

RIDGE—The highest point of a roof.

SASH—The framework which holds the glass in a window.

SHAKES—Hand or machine split sheets of wood used as waterproof siding for exteriors, expecially side walls.

SLEEPER—A timber laid on or near the ground to support a floor joist; also strips of wood, usually 2 x 2 laid over a rough concrete floor, to which the finished wood floor is nailed.

WATER TABLE—The finish at the bottom of a building for carrying the water away from the foundation.

Common Abbreviations. Because of the lack of space on blueprints, it is common practice to use abbreviations for many items. Some of the more common abbreviated items are listed below:

Apt.	—	Apartment
Bm.	—	Beam
Bldg.	—	Building
B.R.	—	Bedroom
C.A.	—	Cold Air
Clg.	—	Ceiling

Clos., C., or C.	Closet
Cem.	Cement
Conc.	Concrete
Det.	Detail
Diam.	Diameter
D.R.	Dining Room
Dr.	Door
D.S.G.	Double Strength Glass
D.H.	Double Hung
Dn.	Down
Drgs.	Drawings
Ea.	Each
El.	Elevation
Ent.	Entrance
Ext.	Exterior
Fin.	Finish
Flash.	Flashing
Fl.	Flooring or Flush
Fur.	Furring
Gar.	Garage
Galv.	Galvanized
G.I.	Galvanized Iron
Gl.	Glass
H.	Hall
Ht.	Height
H.A.	Hot Air
Jb.	Jamb
K. or Kt.	Kitchen
Lt.	Light
Linol.	Linoleum
L.R.	Living Room
Mldg.	Molding
Mull.	Mullion
Mor.	Mortar
O.C.	On Center
O.S.	Outside
O.S. Cas.	Outside Casing
R.	Riser or Radius
Rm.	Room
Sec.	Section
Specs.	Specifications
S.S.G.	Single Strength Glass
Wd.	Wood
Yd.	Yard

The lists of terms and abbreviations given are not the only ones found on drawings. Those given are mainly used by carpenters and are used as examples that can be of interest to people working in the fire-safety area.

The symbols shown are basic, and much more detailed symbols may be shown on the actual drawings. For example, the symbol for a kitchen sink shown in figure 1-5 is fairly simple, the symbol used on a set of drawings may be much more detailed to show the exact style of sink to be installed.

Don't let your knowledge of reading plans run away from you. Your job is to read and interpret the plans and to make sound recommendations. If there is any doubt as to the meaning of symbols or terms on drawings, get a clarification from the expert in that area.

If, during an inspection of new construction, you use a set of drawings, as you should, don't start "raising cane" if you see something that doesn't look right. Check with the construction supervisor first to see if there are any changes that have been approved but that do not show upon your plans. You might just save yourself from an embarrassing situation.

Now go back to figure 1-2 and see if you understand more about the drawing than when you first looked at it.

Exercises (405):

1. For this exercise, refer to figure 1-7, "Symbols used on drawings and blueprints." In the following manner identify those symbols: Take the letter under each symbol in the figure and write that letter into the proper blank below. In other words, match the letter to the correct description found below. Each letter may be used only once, but some descriptions are not used at all.

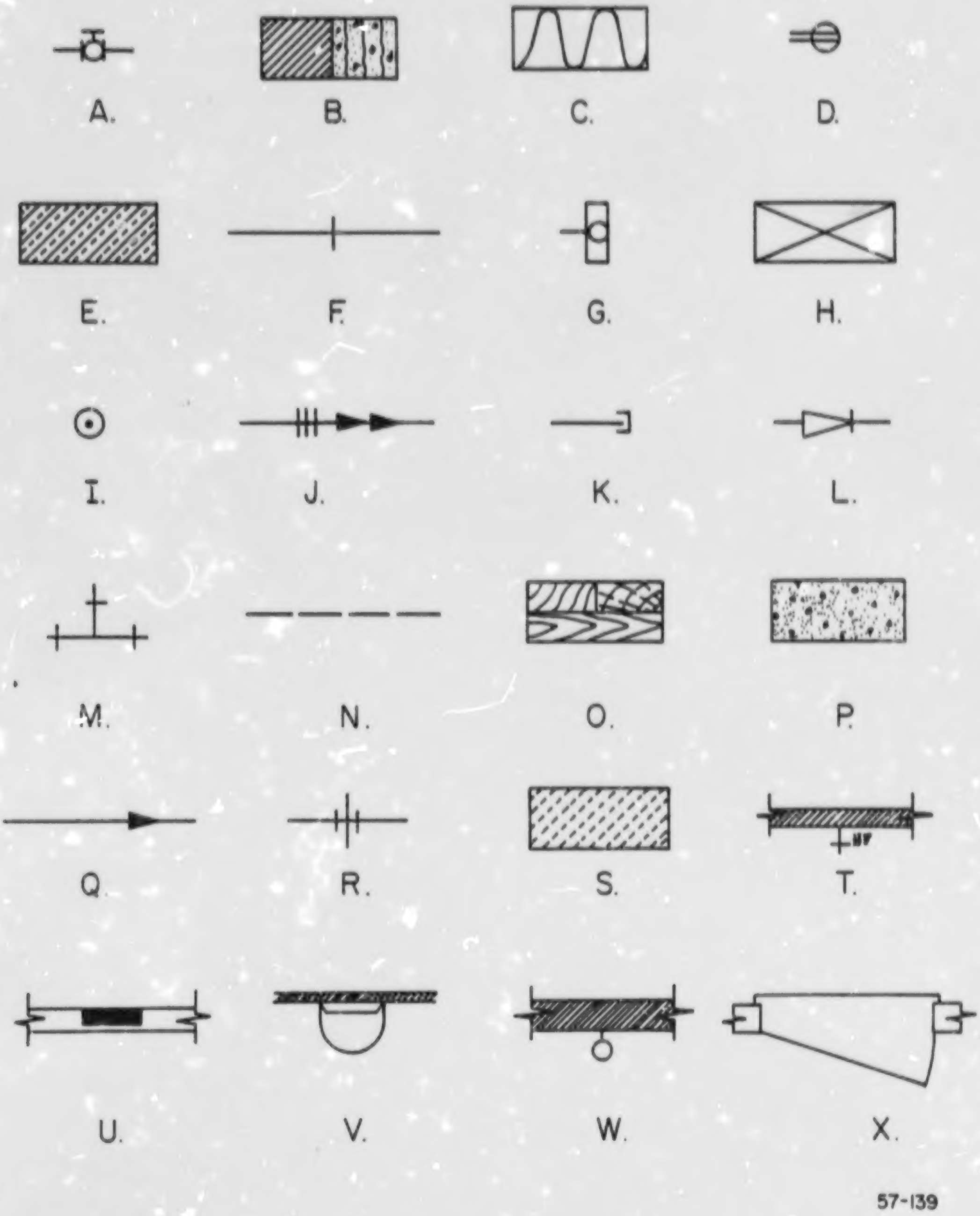


Figure 1-7. Symbols used on drawings and blueprints (objective 405, exercise 1).

___1. Threaded joints in pipe.
___2. A pipe union.
___3. Finish lumber.
___4. A "Tee" in a run of pipe.
___5. A gas outlet.
___6. Loose fill insulation.
___7. Rough lumber.
___8. A valve in a run of pipe.
___9. An electrical branch circuit concealed in the floor.
___10. A lighting panel mounted in a wall.
___11. A hose faucet outlet.
___12. Fire brick or refractory material.
___13. A double hung window in a frame wall.
___14. An electrical outlet in the floor.
___15. A reducer in a run of pipe.
___16. A ceiling heater outlet.
___17. A wall outlet for a fluorescent fixture.
___18. Glass, slate, marble, porcelain, etc.
___19. A door in a frame wall.
___20. A one-circuit two-wire home run to panel.
___21. Concrete block.
___22. A drinking fountain.
___23. A shower head.
___24. Concrete.
___25. A three-wire home run to panel with two circuits.
___26. A pipe cap.
___27. A duplex convenience outlet.

2. Match each of the selected terms listed in column B with its correct definition in column A by writing the correct letter in the blank provided. Each item may be used only once.

Column A	*Column B*
___1. Casement.	a. A timber laid on or near the ground to support a floor joist.
___2. Beam.	b. The highest point of a roof.
___3. Jamb.	c. A vertical window in a small gable rising from sloping roof.
___4. Dormer.	d. The process of instaling glass in window sashes.
___5. Cornice.	e. The side pieces of a finished door or window opening.
___6. Ridge.	f. The portion of the rafters which project from the lower edge of the roof.
___7. Sash.	g. The enlarged portion of concrete located in the bottom of foundation walls to spread the load and prevent setting.
___8. Purlin.	h. A window in which the sash opens upon hinges.
___9. Sleeper.	i. The framework which holds the glass in a window.
___10. Eaves.	j. The horizontal molding around the top of a building just below the eaves.
___11. Glazing.	k. A projection over windows, doors, or porches to afford protection against weather.
___12. Canopy.	l. A horizontal wood, steel, or concrete member used to provide support.
___13. Flashing.	m. Strips of sheet metal or composition roofing material used to waterproof roof intersections and other exposed places on the outside of the house.
___14. Footing.	n. A short joist supporting tall beams and framing between trimming joist; the piece of steel or finish over an opening; or a lintel.
___15. Header.	o. A timber supporting several rafters at one or more points.

3. Match the common abbreviation listed in column B with its correct word(s) in column A by writing the correct letter in the blank provided. No abbreviation may be used twice, and some abbreviations are not used.

Column A	*Column B*
___1. Jamb.	a. Conc.
___2. Beam.	b. Yd.
___3. On Center.	c. O.S.
___4. Wood.	d. El.
___5. Riser or Radius.	e. D.H.
___6. Elevation.	f. Fur.
___7. Double Strength Glass.	g. Ht.
___8. Concrete.	h. Jb.
___9. Building.	i. C.A.
___10. Light.	j. Bm.
___11. Double Hung.	k. O.C.
___12. Hot Air.	l. D.S.G.
___13. Cold Air.	m. R.
___14. Exterior.	n. Jm.
___15. Height.	o. Fl.
___16. Floor or Flush.	p. Wd.
___17. Outside.	q. Bldg.
___18. Yard.	r. Fld.
___19. Outside Casing.	s. Ext.
___20. Cement.	t. H.A.
	u. Lt.
	v. W.I.
	w. Cem.
	x. Yr.
	y. Rsr.
	z. O.S. Cas.

1-4. Exit Criteria

The Life Safety Code was first published by the National Fire Protection Association in 1927. Since then it has undergone numerous changes, some as a result of catastrophic fires in which there were large losses of life. One such fire occurred in 1942 at the Cocoanut Grove Night Club. A great deal of information was compiled from these incidents in the hope that it might be used to prevent such needless losses in the future.

406. Decide as to the validity of statements concerning fire exits and their criteria, and compute exit requirements.

Exit Criteria. In general, fire engineering is concerned with two aspects of building construction: (1) provision of sufficient exits for the safe evacuation of personnel from a facility; and (2) the structural integrity of the building under a fire condition.

Safe exit from a building depends on the provision of exits to give a safe path of escape from fire. The exits are arranged for ready use in case of emergency, and they are of sufficient size to permit all occupants to reach safety before being endangered by fire, smoke, or panic. The exits should permit everyone to leave a fire area in the shortest possible time, assuming prompt discovery, notification of the occupants, and the efficient use of available exits. The exit time should be shorter in high fire hazard occupancies. Time factors are based on traffic counts for assumed safe average rates of travel per file of persons: 60 per minute through doors or along level passageways, 45 down stairways.

There is always a possibility that fire or smoke may prevent the use of one exit. Therefore at least one alternate exit should be provided, one remote from the first. The only exception is in buildings or rooms so small or so arranged that a second exit would not provide an appreciable increase in safety.

Calculation of the requirements for life safety for a facility is explained in NFPA Standard Number 101, the Life Safety Code. The Life Safety code is concerned only with life safety. What happens to a building after all occupants are safely out is of no concern here. Both new and existing structures shall comply with the provisions of the Life Safety Code.

Life safety from fire requires the following conditions, all of which are specified in the Life Safety Code:

- A sufficient number of unobstructed exits of adequate capacity and properly designed, with convenient access thereto.
- Protection of exits against fire and smoke during the length of time they are designed to be in use.
- Alternate exit and means of travel thereto, for use in case the primary exit is blocked by fire.
- Subdivision of areas to provide areas of refuge in those occupancies where evacuation is only a last resort.
- Alarm systems to alert occupants in case of fire.
- Adequate lighting of exits and paths of travel to reach them.
- Signs indicating ways to reach exits where needed.
- Safeguarding of equipment and of areas of unusual hazard which might spread fire and smoke, endangering the safety of persons on the way out.
- Exit drill procedures to assure orderly exit wherever practicable, such as in schools.
- Control of psychological factors conducive to panic.
- Control of interior finish materials and contents to prevent a fast-spreading fire which could trap occupants.

The Life Safety Code covers both new and existing construction, and is intended to provide safety to life from fire in both.

Calculation of the required number and size of exits for a facility is explained in NFPA Standard Number 101, the Life Safety Code. Before calculating exit requirements, you must first understand the meaning of "exits" and of "means of egress."

A means of egress is defined, in the Life Safety Code, as a continuous and unobstructed way of exit travel from any point in a building or structure to a public way. It consists of three parts: (1) the way of exit access, (2) the exit, and (3) the way of exit discharge.

Exit access is that portion of a means of egress which leads to the entrance to an exit.

Exit is that portion of a means of egress which is separated from the area of the building from which escape is to be made—the walls, floors, doors, or other means which provide the protected path necessary for the occupants to proceed with reasonable safety to the exterior of the building.

Exit discharge is that portion of a means of egress between the termination of the exit and the exterior of the building at ground level.

The requirements for the number, type, location, and capacity of fire exits are determined by the occupancy (use) of the facility, the occupant load, and the installed fire protection (sprinklers). Different occupancies are covered in separate chapters of the

Life Safety Code. Standards for panic hardware and exit lighting are explained in detail in specific sections of the Life Safety Code. In addition, the chapters dealing with specific occupancies contain general requirements for such provisions, but they refer the reader back to the more-detailed sections where the specific requirements are listed. Except where otherwise indicated in AFM 88-15, the adequacy of exits and other life safety measures shall be as specified in NFPA Standard 101 (Life Safety Code).

Exit Size. Exits are measured in units of 22-inch widths. One unit is 22 inches in width while the Life Safety Code defines a half unit as 12 inches in width. Where the required exit does not call for more than one unit of exit width, the size of the exit door will be not less than 30 inches wide (28 inches of clear opening) which will be considered one unit of exit. Where practicable, exits will be combined to have at least two units of exit width. No single leaf in an exit will exceed 48 inches in width.

Exit Facilities and Arrangements. Doors should swing with exit travel except for small rooms. Vertical sliding or rolling doors are not recognized as exits. Panic hardware should be installed on exit doors in places of public assembly and schools.

Where doors serve to protect exit facilities, as in stairway enclosures and smoke barriers, they must be kept normally closed to serve their function of stopping the spread of smoke—or, if open, must be closed immediately in case of fire. Fusible-link-operated doors will close from the heat of fire but not from the buildup of smoke.

Panic hardware is used to facilitate safe egress of people from places of public assembly (theaters, schools, clubs, etc.) when a pressure of 15 pounds or less is applied to the releasing device. Normally these devices are not less than two-thirds the width of the door and placed at heights suitable for the service required, not less than 30, no more than 44 inches, above the floor. Underwriters' Laboratories, Inc., in their Building Materials List, list approved types of door hardware.

Exit Lighting and Signs. Illuminated exit signs must be provided for all emergency exits and passageways as required by the NFPA Standard Number 101 except that all new exit signs will be white background with red letters or red background with white letters. These signs are required in theaters, auditoriums, assembly halls, schools, gymnasiums, dormitories, BOQs, clubs, office buildings, dining halls, and similar places of public use.

Emergency light in places of public assembly and in portions of other occupancies, as specified in the Life Safety Code, should be so arranged that the necessary exit illumination will be maintained in the event of a failure of the normal lighting of the building. The normal procedure is to provide such emergency lighting for a period of at least one-half hour. In certain other occupancies, such as hospitals and institutions, a period of 1 hour is recommended.

Where electric battery-operated units are used, suitable facilities should be provided for keeping such batteries properly charged.

Fire Escapes. Exterior fire escapes will be self-supporting structures and will be suitable to the climatic conditions of the locality. Fire escapes should be placed against blank walls, or all openings under or adjacent protected by self-closing fire doors or nonopening metal windows having wired glass. They will be of noncombustible construction. The straight or spiral slide chute is acceptable for fire escapes except for places of public assembly. For buildings with hospital patients, the chutes will be designed to evacuate patients on mattresses.

Ramps. Where there are large crowds, ramps, enclosed and otherwise arranged like stairways, are sometimes used instead of stairways. They are required where differences in floor level would result in less than three steps of a stair. Ramps must have a very gradual slope if they are to be considered safe exits. Open or enclosed exit ramps will not have a slope in excess of 1 foot in 10 feet; and ramps used to evacuate hospital patients will be limited to a maximum 1 foot in a 20-foot slope. A ramp will not be less in width than the exit door leading to it, and it should have a nonslip surface. Open exit ramps will have guard rails.

Fire Drills. Fire-exit drills are essential in schools and are desirable in every type of occupancy so as to assure that the people are familiar with exits. In occupancies such as hospitals, nursing homes, hotels, and apart-houses, drills are usually limited to an exercise of employees, without alarming patients, guests, or customers. Drills should be held once a month or oftener, but not at regularly scheduled periods. They should cover all shifts in an occupancy which is operated 24 hours a day. Drills should be conducted without warning, except to supervisory personnel, and should simulate fire conditions. Frequency, time, and manner of fire evacuation drills should comply with the requirements set up by the authority having jurisdiction to determine such requirements.

Exit Requirement Computations. To actually compute the number and size and locations required in a facility, the correct procedure is as follows:

1. Determine the occupancy and turn to the appropriate chapter in the Life Safety Code. There you will find the square feet required for each occupant, based on net or gross floor area of the facility. The definitions of net and gross floor areas are in a "Definitions" section of the Life Safety Code.

2. Determine the square footage of your facility by multiplying the length in feet by the width in feet and multiplying the result by the number of floors in the facility.

3. Divide the total net or gross square footage by the number of square feet required for each occupant. The result is the occupant (population) load of the facility. That figure represents the maximum number of people normally expected to occupy that building at any one time.

4. Now you must determine the minimum number of exit widths required in the building. Divide the occupant load by the number of floors. The result is the occupant load for each floor.

5. Divide the capacity of each unit of exit width as specified in the Life Safety Code chapter dealing with that class of occupancy into the occupant load of each floor. The result is the required number of units of exit width for that floor. For example, dormitories require one unit of exit width for each 50 persons on the first floor; on the upper floors one unit of exit width is required for each 30 persons. Places of public assembly are exceptions and the appropriate Life Safety Code chapter should be consulted when computing these requirements. One further word of caution is in order at this time. When units of exit width are being computed, use the following rules for rounding off:

a. If the required units fall between a whole number and .5, add on half a unit to the nearest whole number. For example, if your division yields the result 2.2, the actual number of exit widths would be noted as 2.5 according to the rule.

b. If the required units fall between .5 and the next whole number, the correct number of exit widths will be the next whole number. For example, if your division yields 2.6, the actual number of required units of exit width would be 3 according to the rule.

6. Add together the required units of exit width for each floor. The sum is the required number of exit widths for the entire building.

7. Determine the travel distance requirements by using the appropriate Life Safety Code chapter.

8. Determine the required number of actual exits, bearing in mind that the width of a door leaf, as specified in the Life Safety Code and AFM 88-15, will differ from the size of a single unit of exit width. Many types of occupancy are not permitted to have dead ends; meaning, corridors which do not lead to exits.

The Life Safety Code contains guidance to assist you in determining if dead ends are permitted in specific occupancies.

Problem: Determine the required number of units of exit width, the occupant load, and the required number of exits for an unsprinklered, 2-story dormitory 50 feet wide and 100 feet long.

Units of exit required: 50/1 first floor; 30/1 second floor.

Information: The following information is taken from the appropriate Life Safety Code chapters:

200 square feet (gross) are authorized for each person.

Computations:

50 X 100 X 2 = 10,000 square feet (gross)

10,000 ÷ 200 = 50 (total occupant load)

50 ÷ 2 = 25 (persons per floor)

25 ÷ 50 = .5 (units for first floor)

25 ÷ 30 = .833 (units for second floor) round off to 1.0

1.0 + .5 = 1.5 (total number of exits for building)

From reading the appropriate Life Safety Code chapter, we now determine that travel distance cannot exceed 100 feet. NO dead ends are permitted, so we will require four actual exits on this building, one on each end of each floor.

Exercises (406):

If one of the statements, exercise 1 through 14, is correct, mark it True; if it is False, correct it.

___1. The provision of sufficient exits for the safe evacuation of personnel from a facility is one of the two aspects of building construction with which fire engineering is concerned.

___2. At least one alternate exit should be provided, remote from the first, except in buildings or rooms so small or so arranged that a second exit would not provide an appreciable increase in safety.

___3. The Life Safety Code is concerned with life safety and what happens to a building after all occupants are safely out.

___4. Control of psychological factors conducive to panic is one of the conditions of life safety which is specified in the Life Safety Code.

___5. Exit discharge is that portion of a means of egress which leads to the entrance of an exit.

___6. The requirements for the number, type, location, and capacity of fire exits are determined by the occupancy (use), the occupant load, and the available installed fire protection (alarm systems).

___7. Where the required exit does not call for more than one unit of exit width, the size of the exit door will be not less than 48 inches in width.

___8. Fusible-link-operated doors will close from the heat of fire or from the buildup of smoke.

___9. Normally, panic hardware devices are not less than two-thirds the width of the door and located between 30 and 44 inches above the floor.

___10. Emergency lighting in places of public assembly should be so arranged that the necessary exit illumination will be maintained for at least 1 hour in the event of a failure of the normal building lighting.

___11. The straight or spiral slide chute is acceptable for fire escapes except for places of public assembly.

___12. Ramps used to evacuate hospital patients will be limited to a maximum of 1 foot in 10 feet slope.

___13. Fire drills should cover all shifts in an occupancy operated 24 hours a day.

___14. To compute the size and location of exits required for a facility, the first thing you should do is determine the occupant-load of the facility.

The following information is furnished for use in the completion of exercises 15 through 18.

Building occupancy—Dormitory.
Description—Unsprinklered, 3 stories, 30 feet wide by 200 feet long.
Occupant load—200 square feet (gross) per person.
Units of exit required—50/1 first floor; 30/1 second and third floors.
Other—No dead ends allowed; maximum travel distance 100 feet.

15. The total occupant load for this facility is___.

16. The maximum number of persons for the second floor should be__________.

17. The number of units of exit required for the third floor is__________.

18. The minimum number of exits required for this facility is__________.

CHAPTER 2

Fire Detection and Suppression Systems

IMAGINE YOURSELF as the fire chief at an Air Force base. How would you like to have working for you firemen who would need the minimum amount of personal attention, would be on duty 24 hours a day, 7 days a week, could be at the scene of a fire immediately, and could work just as efficiently in dense smoke and gas as in fresh air? You are probably thinking that this would be a fire chief's dream, but that it is also impossible. Well, the dream *can* be realized. We achieve that dream not by depending on people, but by depending on devices—on devices we group under the heading of "installed fire protection."

We determine requirements for installed fire protection much as we determine manpower requirements. Policies and requirements are set down for you as guidelines to show you where installed fire protection systems must be used. Once you have decided that a system must be used, you must then decide the kind, class, or type. Then a decision is needed as to how and when the system will operate. Once you have decided when and how the system will operate, you must decide when to inspect it, when to service it, and when to maintain it. All these decisions should be made before the building/facility is constructed. In those cases where the building/facility has already been constructed, then your constant review for adequacy can keep your "iron firemen" up to date and efficient.

With the exception of some small remote sites, you will normally find at least one installed system at any Air Force base. Many bases have more than one installed system, and many will have more than one *kind* of installed system. In order for you to appraise the fire protection facilities on your base, you must consider the condition and adequacy of these installed systems. To do this you must understand their operation. You must also know how to inspect, service test, and maintain them. Your thorough understanding will help you to develop better methods of using them for maximum efficiency. In other words, your knowledge of inspecting, testing, and maintenance will help to insure the proper operation of these systems when they are needed.

2-1. Requirements for Fire Detection and Suppression Systems

The various systems of installed equipment, such as the sprinkler and alarm systems, are the chief elements of fire protection in the Air Force. Installed fire protection systems are found in many buildings of an Air Force base. You can get a complete listing of the types of buildings that will be equipped with installed fire protection systems by referring to AFM 88-15, *Air Force Design Manual—Criteria and Standards of Air Force Construction.* As much as possible of the information from AFM 88-15 will be in this chapter for your reference.

It would be good if every building on all Air Force installations were equipped with installed systems, because valuable property and probably many lives could be saved. However, it is impossible to do so because of the tremendous cost for the installation and maintenance. The requirements for installed systems are many. Following are the most important requirements.

407. Complete statements concerning fire detection and alarm systems and their requirements.

Fire Detection and Alarm Systems. Basically these systems are detectors and transmitters operated either manually or automatically.

Automatic fire detection and alarm systems. Automatic fire detection and alarm systems will be installed in buildings as outlined below:

a. They will be installed where safety to life, need for early detection, and notification of fire are of principal concern.

b. They will be installed in buildings which normally would require automatic sprinkler systems but where conditions and circumstances make such installations impracticable.

c. Areas protected with automatic fire detection systems will normally include occupied spaces, unoccupied spaces, and attics containing utility services. This includes other areas where fire is likely to originate and remain unnoticed.

d. Automatic fire detection and alarm systems with supplemental manual boxes will be installed in:

(1) Buildings, for protection of life, or in isolated and/or important facilities where automatic sprinkler protection would normally be provided but is not economically nor technically feasible.

(2) Type "C" buildings used for confinement of military prisoners where automatic sprinklers, normally provided, cannot be made available.

(3) Type "C" buildings of hospital groups where automatic sprinklers are not provided.

(4) Living quarters, guest houses, and similar buildings used for sleeping purposes. The automatic fire detection system will be activated by smoke detectors installed in sleeping rooms or areas. This type system will be incorporated in design of new military and civilian dormitories and officer quarters as an alternate/additive in lieu of manual fire and evacuation systems and will be included in initial construction when within congressional cost limitations.

(5) Service clubs and open messes unless protected by automatic sprinklers.

(6) Nurseries and child-care centers.

The criteria for modifying existing buildings for missile support or similar missions must include the adequacy of existing detection and alarm systems. Existing heat-actuated detectors will be used as an automatic fire detection system when an existing deluge system is to be changed to a closed-head type. Automatic fire detection and alarm systems will be provided as required in new areas which are not required to have sprinklers. All systems will transmit a fire signal to a central alarm location by either coded transmitters or other acceptable devices.

Automatic fire detection and alarm equipment for modernizing of mobilization-type airmen's dormitories. An automatic fire detection and alarm system is required for these dormitories by fire protection criteria. Modification of existing equipment and installation of new equipment will be done as follows:

a. Where it is practicable, the existing fire detection and alarm system should be modified as required. New parts are to be furnished by the same manufacturer as of the original equipment. The reinstallation will not be required to conform with the current guide specification, "Automatic Fire Detection and Alarm Systems."

b. Where a completely new automatic fire detection and alarm system is required, the guide specifications for "Automatic Fire Detection and Alarm Systems" will be followed.

c. Working drawings and project specifications will be modified to comply with current criteria.

Smoke detection for dormitories and officers' quarters [modernization program]. When rehabilitated or modernized, all existing dormitories and officers' quarters will require fire detection and alarm systems activated by smoke detectors in sleeping rooms or areas.

Smoke detector(s) located in exhaust or return air plenums to shut off fans will be interlocked with the building fire alarm system. Smoke detector(s) so provided will be installed according to NFPA Standard 90A.

Waterflow alarms. Waterflow alarms, arranged to give both a local and transmitted signal, will be installed on all automatic sprinkler systems:

a. Each alarm check valve and dry-pipe valve will have an alarm transmitter and circuits which will transmit, to a central alarm location, a coded signal which indicates the operation of the system. The sprinkler alarm transmitter may be either pressure-actuated or electrically operated. Where interior alarm facilities are used to transmit waterflow alarm signals, the transmitter will be of an approved type, suitable for use on the existing system.

b. Waterflow (paddle-type) indicators, where installed, will transmit a coded signal to a central alarm location, indicating operation of the sprinkler system.

c. Interconnection will be the responsibility of the base communication officer or of other appropriate communication base activity. Where it is not economically or technically feasible to transmit the waterflow alarm signal of small automatic sprinkler installations to a central location, the sprinkler system will be designed to actuate a local alarm bell located at a point capable of being heard by responsible personnel.

d. Generally one exterior local noncoded waterflow alarm of the electric or the water-motor gong type will be provided for each underground supply connection. These alarms will operate continuously until manually cleared. Where local alarms are electric for wet-pipe or deluge systems, the power supply will be connected on the line side of the main house switch. Where local alarms are electric for dry-type sprinkler systems, their electric circuits will be connected to the electric circuits installed for the heating unit in the valve house. Exterior building local alarms will not be provided on sprinkler systems in buildings of hospital areas. One local low-air-pressure electric gong will be installed at each dry-pipe valve house. Electric circuits for this alarm will be connected to the circuits of the heating units in the valve house.

Manual fire and evacuation alarm systems. Manual fire and evacuation alarm systems will be installed in buildings housing 20 or more persons not otherwise provided with automatic fire suppression or automatic detection systems.

Exterior fire-reporting systems. Exterior fire-reporting facilities will be installed in certain areas to provide means of manually reporting fires. Exterior fire-reporting systems of the supervised telephone or wireless type will be provided in built-up areas and recurrent operational areas, regardless of the existence of buildings and structures. These areas will include, but will not be limited to, aerospace vehicle parking, fueling and maintenance aprons, multipurpose wing hangars, maintenance docks, or similar structures superimposed upon or located next to aerospace vehicle aprons. Fire-reporting facilities ordinarily will not be provided at isolated small areas, ammunition and ordnance storage, and similar restricted areas where personnel are not usually present to detect fires. Furthermore, they are not required in nonhazardous areas where there are adequate administrative phones.

Fire-reporting telephone stations will be located preferably at street intersections approximately 1000 feet apart. Fire-reporting telephone stations are required within 300 feet of fueling system bulk and operating storage and pump houses, meter pits, fill stands, and hydrant fueling points. They will be installed no closer than 150 feet to fueling hydrant, fill stands, or similar loading or unloading points.

Fire-reporting telephone stations should be located within 300 feet of all fixed fueling points and within 500 feet of other aerospace vehicle parking and servicing points. Posts for mounting fire-reporting telephones at aerospace vehicle parking, fueling, and maintenance aprons will not extend more than 24 inches above finished grades. The ruby identification light and telephone on these posts will not extend above the post. For large, mass aerospace vehicle parking aprons, low post- or building-mounted fire-reporting telephones will be installed, outside the apron, in such a peripheral pattern that no parked aerospace vehicle will be more than 600 feet from a fire-reporting telephone. Peripheral spacing will generally be 300 feet, center-to-center.

Fire reporting telephones will connect, normally, over separate circuits to central fire reporting switchboards. Wireless fire reporting transmitters will be coded and limited to 25 transmitters to each receiving device.

Alarm Transmission. Manual fire alarm and automatic fire detection and alarm systems will transmit a coded signal to a central alarm location. Interconnection into existing fire alarm recording equipment will be made before acceptance.

Exercises (407):

Fill in the blanks in the following statements.

1. The selection of a particular fire detection and alarm system, or their components, is determined by the __________ __________.
2. Where safety to life, and a need for early detection and notification of fire are of principal concern, ________ ______ ______ ______ ______ ________ will be installed.
3. Type"C" buildings used for confinement of military prisoners, where automatic sprinklers are not available, will have installed automatic fire detection and alarm systems with ________ __________ ________.
4. When an existing deluge system is to be changed to a closed-head type system, __________ __________ __________ will be used as an automatic fire detection system.
5. In mobilization-type airmen's dormitories, the existing fire detection and alarm systems should be modified as required for the purpose of modernizing where it is________.
6. When existing dormitories are rehabilitated, required fire detection and alarm systems will be activated by__________ ________ in sleeping rooms or areas.
7. Smoke detector(s) located in exhaust or return air plenums to shut off fans will be interlocked with the ________ ________.
8. Each alarm check valve and dry-pipe valve will have an alarm transmitter and circuits which will transmit, to a central alarm location, a coded signal which indicates the ________ ___ ___ __________.
9. Paddle-type waterflow indicators, where installed, will transmit a ________ ________ to a central alarm location.
10. Where local alarms are electric for wet-pipe or deluge systems, the power supply

will be connected on the ________ ________ of the ______ ______ ______.

11. When not otherwise provided with automatic fire suppression or automatic detection systems, manual fire alarm and evacuation systems will be installed in buildings housing ________ ____ ________ persons.
12. Exterior fire-reporting facilities will be installed in certain areas to provide means of __________ ________ __________.
13. Fire-reporting telephone stations will be located preferably at street intersections approximately ________ ________ apart.
14. Fire-reporting telephone stations will be installed no closer than ________ ________ to fueling hydrants.
15. The identification light and telephone on a post at a maintenance apron will not extend more than ______ ________ above finished grades.
16. You should not have to travel more than ________ __________ from a parked aircraft to reach a fire-reporting telephone.
17. Wireless fire reporting transmitters will be coded and limited to ________ transmitters to each receiving device.

408. Cite factors in the determining of requirements for installed fire protection systems and for the installation of these systems.

Factors in Determining Requirements. The need for installed fire protection systems for either complete coverage or localized areas will be carefully considered. The need for installed fire protection systems will be justified by the following factors:

a. Where the omission of such protection will result in conditions hazardous to life and property.

b. Relative importance of the particular supplies or facilities.

c. Relative quantity of supplies or facilities to be protected as compared to the available supplies or facilities of the same type.

d. The ability to replace supplies or facilities, including consideration of replacement time, manpower, materials, and costs.

e. Potential severity of fire damage due to inherent hazard of structure, stored material, or processes.

f. Other adequately protected facilities which can be used.

g. Present and future advantages which would justify the cost of such protection.

h. Size of building, value of the materials or processes as related to fire protection from available firefighting resources.

i. Permanent or temporary use of base and building under consideration.

j. Where protection is required from local conflagration hazards.

Now let's take a look at requirements for fire extinguishing systems in general.

Automatic sprinkler systems. The automatic sprinkler systems will be provided in facilities and areas to insure the maximum degree of life safety, or to insure property protection where the size, type of construction, occupancy, or other conditions create severe monetary or strategic fire loss potential. Also, this protection will be provided where the probability of fire severity is beyond the capability of control by local firefighting forces or water supplies.

Wet or dry, closed-head, automatic sprinkler systems will be installed in buildings and structures of the following occupancies: (Installations in areas not normally heated or where otherwise desirable due to climatic conditions will be of the "dry"-pipe type).

a. Type "C" hospital buildings, occupied by bed patients; and other type "C" buildings which constitute a fire exposure to buildings occupied by bed patients.

b. Buildings or structures of type "C" construction used for:

(1) Confinement of military prisoners.

(2) Dormitories and quarters having areas larger than current definitive drawings, or of three stories or more in height.

(3) Wharves and substructures of piers.

(4) Administration, logistics or training, where justified by the importance of the service, the probable frequency and potential severity of fire damage, or the absence of other similar facilities essential to the mission.

c. Warehouses, sheds (including transit and pier sheds), airfreight terminals, and similar storage-type buildings containing combustible materials, flammable liquids, or supplies of a critical nature, severe fire hazard, high monetary value, or of vital importance. (Type "C" or "N" construction). NOTE: Automatic sprinkler protection is to be used for type "N" construction only when contents are combustible, or where operations create fire or explosive hazards.

d. Technical- and industrial-type buildings, including shops and laboratories which are used for production, repair, experimental testing, electronics, overhaul facilities, or other processes; services or equipment of a critical nature, severe fire hazard, high monetary value, or of vital importance. (Type "C" or type "N" construction.)

e. Service clubs, open messes, sales exchange stores, commissaries, cold-storage plants, laundries, dry-cleaning plants, and other commercial or recreational facilities where areas approximate or exceed 20,000 square feet or where contents are of high monetary value. (Type "C" or type "N" construction.)

f. Windowless and underground structures when the combustibility of the contents or life safety features warrant the protection.

g. Areas of buildings of type "N" construction, where significant amounts of combustible materials are stored or where operations create fire or explosive hazards, including tape storage rooms. Such areas will be separated from unsprinkled areas by fire walls or fire partitions.

h. In certain areas of type "N" hospital buildings, such as general storage and supply rooms; large janitor closets; trash collection rooms; soiled linen collection rooms; storage rooms for patients' clothing, occupational therapy rooms, where combustible craft material is used; pharmacy, including compounding room and storeroom, supply rooms for flammable liquids and gases, furniture and mattress shops, work and general repair shops, such as paint, carpenter, furniture, and electric, storage cabinets, and vaults containing nitrocelluose film.

i. Hangars, docks, or similar facilities of type "C" or type "N" construction for operational use, training, storage, checkout or assembly, maintenance, modification, or other processing of aerospace vehicles where the total floor area with or without shops is 24,000 square feet or more. Deluge-type systems will be installed in hangar areas. Shop areas will have the closed-head-type system if separated from the hangar area by fire partitions or fire walls and fire doors. Water storage capacity for deluge systems will have a minimum of 45 minutes duration.

j. Buildings or parts of buildings housing critical material as defined below:

(1) Buildings for housing installations for special training devices and equipment, such as flight simulators, link trainers, celestial navigation trainers, combat information center (CIC), and gunnery trainer.

(2) Buildings for housing of electronics, radio, radar, sonar, photographic, optical, or other similar types of equipment used for operational purposes or training; or manufacture, assembly, and/or repair. This type shall include electronic computers and weapons fire-control equipment.

(3) Buildings for storage of training devices and other equipment as listed above, fly-away kits, aircraft engines, and similar vital spare parts and components.

(4) Other buildings housing critical material in sufficient amounts. This critical material includes equipment, devices, apparatus, and supplies which meet one of the following conditions:

(a) Essential to the accomplishment of vital military missions.

(b) Exceptionally costly.

(c) Normally in short supply.

(d) Highly complex.

(e) Requiring a long lead-time for procurement.

k. Combustible water cooling towers that are a component of a critical or strategic service or operation, the loss of which would be a serious handicap to an important mission; and combustible water cooling towers that are of large capacity and of high monetary value where they are exposed to spark-producing operations, hazardous processes, or combustible structures. Exceptions to the above are that sprinkler protection may be omitted in combustible cooling towers at strategic sites provided each site has two cooling towers with each tower having a cooling capacity to meet essential operational demands, and the two towers are located remotely from each other.

l. Automatic sprinkler systems (deluge or closed head) will not be installed in hangars, docks, or missile assembly buildings where the total floor area including shops is less than 24,000 square feet. Such systems will not be installed in alert hangars or shelters, regardless of their area. Exception to these two considerations must have approval of Hq USAF.

Special fire suppression systems. Special fire suppression systems, such as foam, water spray, carbon dioxide, bromotrifluoromethane (Halon 1301), and dry chemical may be installed in areas or spaces, other than those noted above, where there is an easily ignitable and rapid burning substance in the nature of flammable dust, vapors, or liquid. Such systems will be installed, when warranted, in cabinets and other small enclosures housing critical material which is combustible or which presents a fire or explosion hazard. Facilities in which critical material warranting fire protection is in use, but which are under continuous surveillance by operating personnel, such as aircraft control towers, and radio transmitter and receiver facilities, may not require installed fire extinguishing equipment.

In that event, adequate portable fire extinguishing equipment will be provided.

Fire department connections. Automatic sprinkler systems will normally include a Siamese connection to permit fire department pumpers to support and replenish water supply to the sprinkler system. The fire department connections are to be used when the pressure or flow is reduced below the designed capacity. Fire department connections will be omitted on open-head deluge systems. They will also be omitted on sprinkler systems supplied directly from the building's internal domestic water system, and on localized systems protecting small areas in the interior of large area buildings.

Exercises (408):

1. How does their cost influence the installation of installed fire protection systems?

2. Automatic sprinkler systems will be provided where the probability of fire severity is beyond what capabilities?

3. Dry-pipe-type closed-head automatic sprinkler systems will be installed in what locations?

4. Automatic sprinkler systems will be installed in administration, logistic, or training facilities under what conditions?

5. When will automatic sprinkler systems be installed in type "N" warehouses, sheds, etc.?

6. For an automatic sprinkler system to be installed in an open mess or service club, that facility must be of what type construction and how large?

7. Sprinklered areas in facilities of type "N" construction will be separated from unsprinklered areas by what means?

8. Hangar areas, where authorized, will have what type of automatic sprinkler system installed?

9. What are the water supply requirements for a deluge system installation?

10. Automatic sprinkler systems will not be installed in hangars, docks, or missile assembly buildings under what conditions?

11. When warranted, how will special fire protection systems be installed?

12. What type of protection will be provided for facilities in which critical material warranting fire protection is in use but which are under continuous surveillance by operating personnel?

13. Under what conditions will fire department connections be omitted from automatic sprinkler systems?

2-2. Types of Fire Alarm and Detection Systems

The Air Force has a huge investment in buildings and equipment. Consequently, it has a large investment in the fire department to protect those buildings and equipment. However, all the equipment, manpower, and facilities of the fire department are of little value unless there is a fast and accurate method of notifying the base fire department where and when a fire has started. This is the purpose of a fire detection and alarm system. In the following paragraphs, we will discuss the classifications of fire alarms and the types of alarms which transmit the signals.

409. Briefly explain how alarm systems are classified and how the various types of alarm systems operate.

Classification and Types of Alarm Systems. The fire alarm systems are generally classified as either *coded* or *noncoded.* It depends upon the type of signal that is transmitted to, and received at, some central location. In the coded

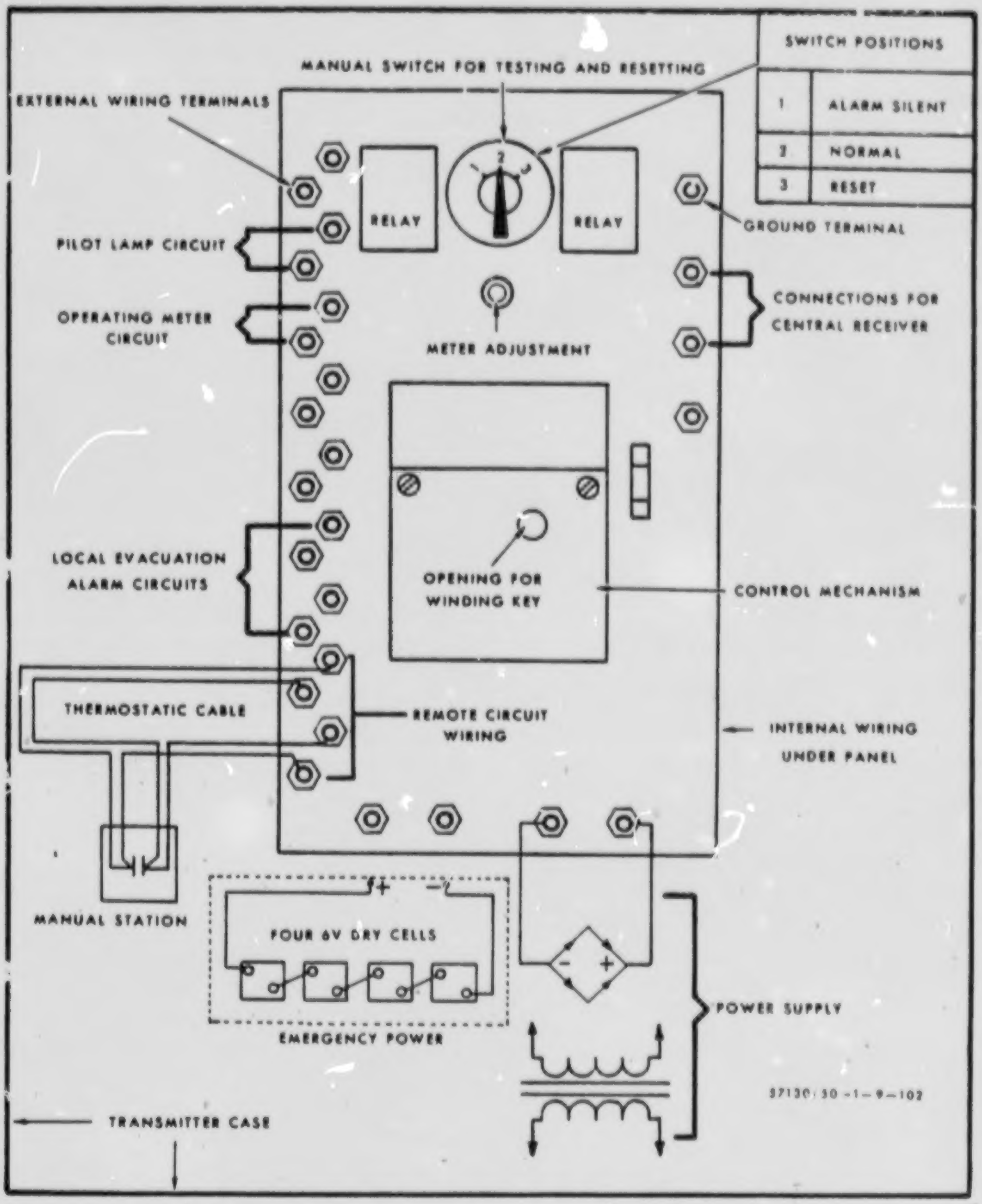

SWITCH POSITIONS
1 ALARM SILENT
2 NORMAL
3 RESET
MANUAL SWITCH FOR TESTING AND RESETTING
EXTERNAL WIRING TERMINALS
RELAY
1 2 3
RELAY
GROUND TERMINAL
PILOT LAMP CIRCUIT
OPERATING METER CIRCUIT
CONNECTIONS FOR CENTRAL RECEIVER
METER ADJUSTMENT
OPENING FOR WINDING KEY
CONTROL MECHANISM
LOCAL EVACUATION ALARM CIRCUITS
THERMOSTATIC CABLE
REMOTE CIRCUIT WIRING
INTERNAL WIRING UNDER PANEL
MANUAL STATION
+
−
FOUR 6V DRY CELLS
EMERGENCY POWER
−
+
POWER SUPPLY
57130:30-1-9-102
TRANSMITTER CASE

Figure 2-1. Automatic transmitter circuits.

alarm system, the signal originates at the transmitter or actuating device and is sent as an intermittent signal to the central location. Here the signal is recorded on a paper tape and initiates some sort of sounding device. The intermittent signal is in the form of a code that gives the location of the sending device. The noncoded alarm system achieves the same result by means of a continuuous signal sent to the central location, which sounds a horn or noise device and lights a pilot lamp. This lamp indicates the location of the device that caused the signal. There are basically three types of alarms: the manual, the automatic, and the composite. Each type may transmit only one or possibly both classifications of signals.

Manual fire alarm systems. In the manual fire alarm systems, the coded or noncoded signals originate from manually operated fire alarm boxes or stations. If automatic sprinklers are installed in the area protected by the manual system, a waterflow attachment is usually tied into the alarm circuit. This attachment sends out an automatic signal when the sprinkler system starts operating.

Automatic fire alarm systems. In the automatic fire alarm system, the coded or noncoded signals are produced by actuation of fire detectors. These detectors will operate in response to abnormally high temperatures, rapid rises in temperature, or some other unusual condition. The automatic fire alarm system may also have supplementary manual fire alarm boxes or stations to permit manual transmission of fire alarm signals. As in the case of the manual fire alarm systems, here too, we can have automatic sprinkler systems installed in the same protected area, and the waterflow alarm attachment will send a signal when the sprinkler system begins to operate.

Composite fire alarm systems. As you have probably guessed by now, there is no standard type of fire alarm system adopted by the Air Force. Generally speaking, each base has a system that is actually a combination of several systems it has developed over the years. This is the natural result of many manufacturers' making a variety of similar components that can be tailored to fit a specific situation. For example, one manufacturer offers 20 basic control panels, and—by a combination of these panels and the various transmitting and actuating devices—over 200 different fire alarm systems can be developed.

However, and fortunately for you, the principles of operation and general procedures for inspections, service testing, and maintenance on the fire alarm systems do not vary greatly. We say that there is no one common system; and that in actual operation each system must be treated individually. Therefore you have to go to the manufacturer's operation and maintenance manuals to get your technical guidance for the particular systems on your base.

Exercises (409):

1. What does the classification of a fire alarm system depend upon?

2. What is the purpose of the pilot lamp in a noncoded alarm system?

3. In a manual fire alarm system, where do the signals originate?

4. What happens in an automatic fire alarm system when a fire detector is actuated?

5. What, if any, is the purpose of supplementary manual fire alarm boxes or stations in an automatic fire alarm system?

6. What is a composite fire alarm system?

7. What publication(s) should you use to find technical guidance for the alarm system(s) on your base?

410. Describe the operation of specific elements/functions of given transmitting and actuating devices.

Transmitting and Actuating Devices. Automatic alarm signal transmitters, sometimes referred to as control panels, send signals which indicate the operation of actuating devices such as manual fire alarm boxes, automatic fire detectors, or sprinkler-system attachments. The transmitters have many of the same features as the control fire alarm receiver, but normally monitor only a given

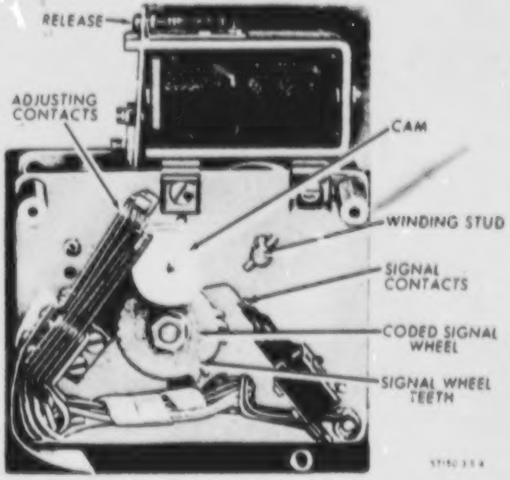


Figure 2-2. Automatic transmitter control mechanism.

area, such as one building or a specific area in a building. In this capacity the transmitter functions separately and does not send an alarm signal to a central receiver to form a fire alarm system.

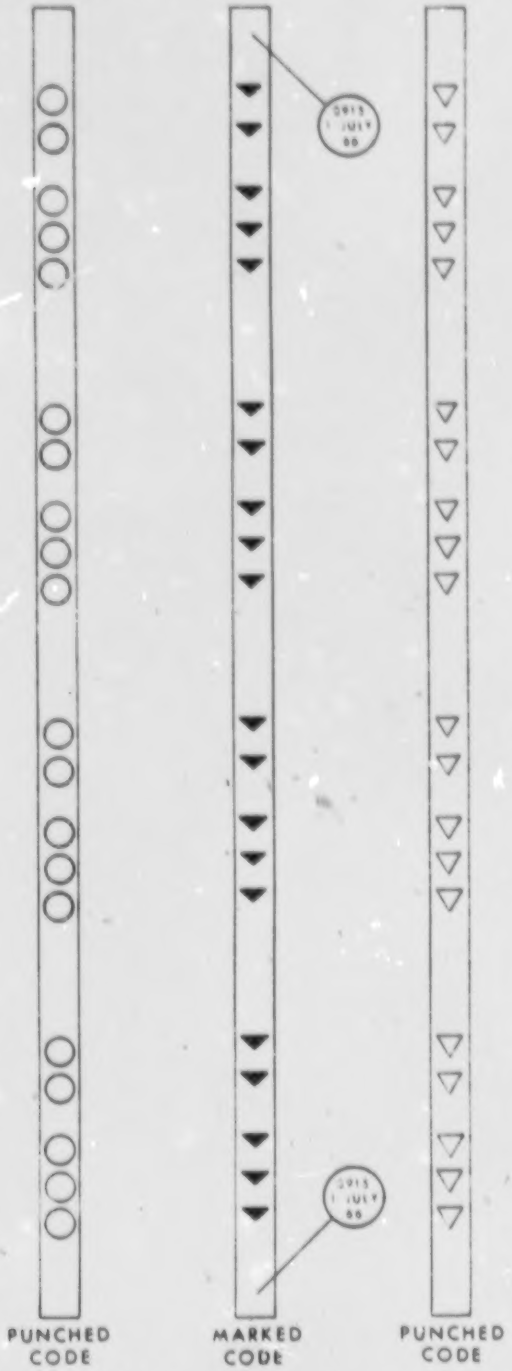


Figure 2-3. Coded paper tapes.

The following system transmitting and actuating devices are classified according to their design and intended application:

(1) Automatic transmitters used with non-coded actuating devices to produce coded signals.
(2) Manual fire alarm boxes.
(3) Automatic fire detectors.
(4) Fire phones.

Automatic transmitters. The automatic transmitter consists of a power supply, remote circuit wiring, a local evacuation alarm circuit, and the control mechanism and connecting terminals for internal wiring connections, as shown in figure 2-1. The primary power source for the transmitter is 110-volts ac. An emergency power source, such as wet-cell storage batteries connected to a charger, may be used. Dry-cell batteries may be used in place of wet cells for emergency power. Although dry cells eliminate the need of a battery charger, they must be changed periodically. Other circuits used to sound local evacuation alarms may be controlled automatically by the transmitter. These local alarms do nothing more than alert occupants and warn them to leave the area.

The transmitter usually has a spring-motor-operated control mechanism, as shown in figure 2-2, with a coded signal wheel. Notice that the signal wheel has teeth arranged in groups to correspond to the identifying number assigned to that transmitter. The control mechanism has contacts which are normally closed. When an actuating device on the transmitter's remote circuit is operated, the control mechanism is released and rotates the signal wheel, which, in turn, causes the signaling contacts to open and close. This produces groups of intermittent impulses in the alarm system circuit. These impulses are reproduced on the alarm system receiver and register in the fire department alarm center, thus identifying the number assigned to the transmitting device.

Let's visualize a fire alarm signal being received, and imagine seeing and hearing the code 3-2 being punched out on the paper-punch register at the central receiver: 3 punches (short pause), 2 punches (long pause), then repeated, as shown in figure 2-3. This operation may be repeated as many as four times, or "rounds," as this operation is sometimes called.

Other contacts on the actuating device are controlled by cams on the signal wheel shaft, shown in figure 2-2. These contacts complete electrical adjusting features under various operating conditions of the transmitter circuit. When the transmitter is restored to normal, it

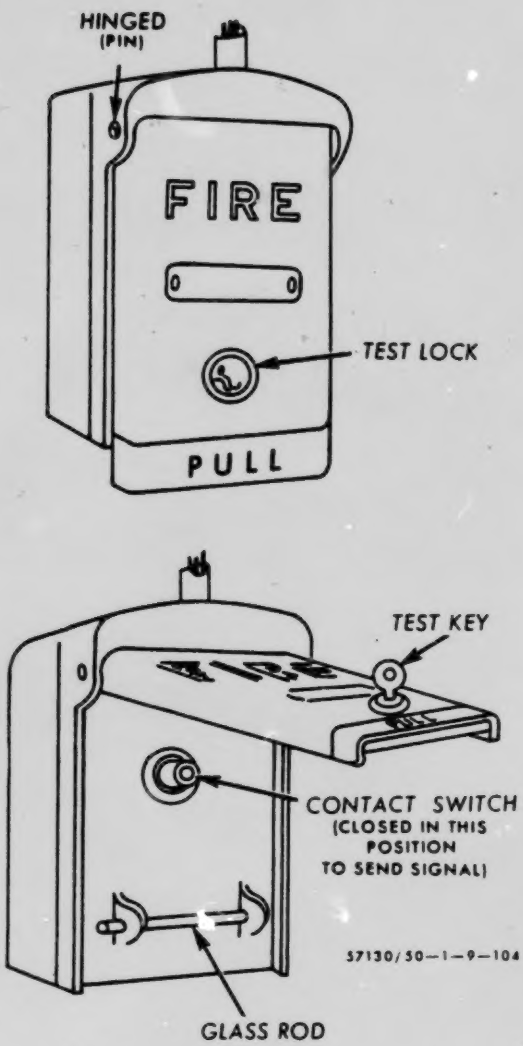

HINGED
(PIN)
FIRE
TEST LOCK
PULL
TEST KEY
CONTACT SWITCH
(CLOSED IN THIS
POSITION
TO SEND SIGNAL)
57130/50—1—9—104
GLASS ROD

Figure 2-4. Manual fire alarm box (noncoded).

may operate for one round, sending a "restoration" signal; or it may be back "in service" after the normal signal cycle of four rounds.

In the normal standby condition, the transmitter actuating device and power supply circuits are closed and provide electrical supervision or monitoring. That is, a break in the remote circuit wiring or a failure of the power supply causes the transmitter to send a one-round trouble signal as a warning of electrical trouble. Also, when a ground occurs in the remote circuit wiring, the transmitter will send a one-round trouble signal.

A transmitter designed to provide emergency operation when a break in the remote circuit wiring exists will automatically adjust its circuits by cam-operated contacts after the one-round trouble signal has been given. Subsequent operation of an actuating device causes the transmitter to produce an alarm signal consisting of one round less than the number produced under normal operating conditions.

Manual Fire Alarm Boxes. These boxes are distributed at accessible locations and operated by hand. The alarm may be transmitted through remote circuits, either directly to the central fire alarm receiver, or through a transmitter to the central receiver. Local evacuation alarms may be connected to the manual alarm box. These evacuation alarms may sound throughout an entire building or only in the local area near the manual alarm box. There are many types and designs of the noncoded or coded manual alarm boxes, and they work in various ways. We will only describe the operation of two such boxes.

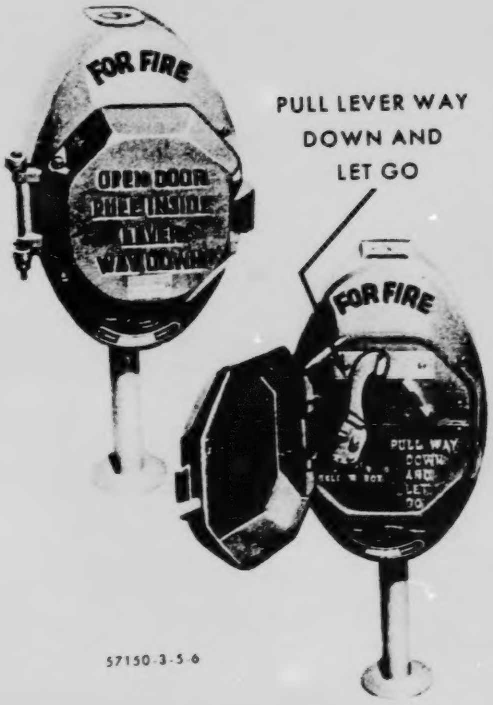

FOR FIRE
OPEN DOOR
PULL INSIDE
LEVER
WAY DOWN
PULL LEVER WAY
DOWN AND
LET GO
FOR FIRE
PULL WAY
DOWN
AND
LET
GO
57150-3-5-6

Figure 2-5. Manual fire alarm box (coded).

Noncoded alarm box. When a glass part is broken, handle pulled, or door opened on the manual noncoded alarm box, as shown in figure 2-4, the contact controlling part moves to close the electrical contacts inside the box. A continuous signal is transmitted when the electrical contacts are closed.

Coded alarm box. The manual coded alarm box, shown in figure 2-5, is made either with or without a latch that requires a glass part to be broken in order to open the door or otherwise get at the operating lever. When the operating lever is pulled, it winds a spring, which, in turn, drives the gear mechanism. When the lever is released, the gear mechanism then rotates a signal wheel which operates contacts for a number of coded signal rounds.

Automatic Fire Detectors. Automatic fire detectors are installed inside buildings to produce a fire alarm signal when the temperature reaches or exceeds a certain value. Basically all automatic fire alarm systems incorporate some type of device that reacts to heat, smoke, or light. These devices trigger an electrically operated mechanism which sends a signal to the central fire alarm center. Generally a local evacuation alarm will be sounded at the same time the signal is transmitted.

A thermostat-type fire detector consists of a thermal element and electrical contacts which can be connected to a signaling circuit either individually or in groups. The thermostat can be designed for spot distribution, using detector units. After operation, some of these thermostat-type detectors will reset themselves. In other detectors some parts or the entire detector must be replaced. This will depend upon the type or model of detector used and the severity of the fire.

Automatic fire detectors are classified according to the manner in which they are triggered, whether it be by heat, smoke, or light. Heat detectors can be divided into such types as fixed-temperature, rate-of-rise, and combined fixed-temperature and rate-of-rise.

Fixed temperature. A fixed-temperature-type detector operates at a definite temperature regardless of the rate at which the temperature rises. The electric circuit in these thermostats is usually completed by the fusing of a metal alloy or by the movement of a bimetallic part. The bimetallic thermostat is the most commonly used. It has a bimetallic strip that moves to touch a fixed contact mounted inside. The temperature at which the unit operates is determined by the distance the bimetallic strip must move to touch the contact. The snap-action disc thermostat employs a disc which changes shape, moving from concave to convex. When the operating temperature is reached, the disc snaps out and causes the movable contact to touch the fixed contact, as you can see in figure 2-6.

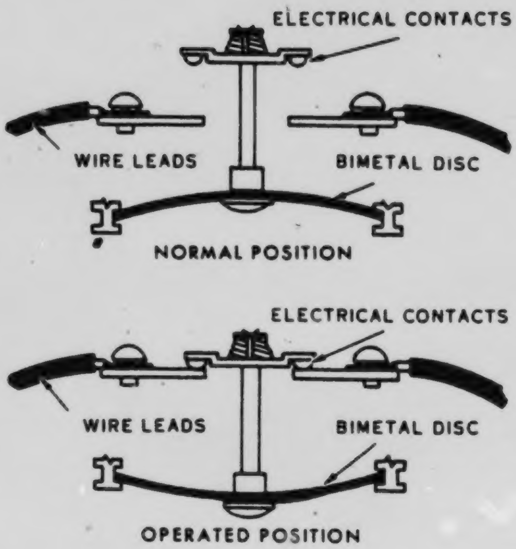


Figure 2-6. Snap-action elements of thermostat.

Thermostatic cable is a line-type fixed-temperature detector that has the thermally sensitive element in a continuous line. It consists of a pair of twisted-steel-wire conductors that are insulated from each other by a thermo-plastic insulation. The heat causes the insulation to soften, and the pressure exerted by the twisted spring wire forces the wires together, thus making an electric contact.

Fixed-temperature thermostat detectors are similar to sprinkler heads in that they are manufactured with different temperature ratings. This permits the selection of a detector with the correct rating for the maximum normal air temperature for a given protected space. The temperature rating is the value at which the fixed temperature element operates when a thermostat is heated slowly so that all parts are heated uniformly. The rate-of-rise feature of a combined fixed-temperature and rate-of-rise detector has no temperature rating.

The temperature rating of the fixed-temperature thermal element is selected after consideration has been given to the prevailing ceiling temperature. Generally the ceiling temperature is below 100° F, but because of installed equipment (boilers, ovens, etc.), the temperature near such equipment may be considerably higher. Accordingly, spot, and line thermostat detectors are selected to give the desired protection and to guard against false alarms.

Rate-of-rise. Rate-of-rise detectors are designed to permit operation when a sudden change in temperature occurs, normally at a rapid rate caused by a fire. This type of detector is effective over a wide range of temperatures and is used in low- and high-temperature areas. In the spot-distribution type, the operation is triggered by the expansion of heated air in a vented chamber.

The pneumatic tube detector, a line-type detector consisting of a continuous length of tubing not exceeding 1000 feet and usually of soft-drawn copper, is installed under the ceiling of the protected buildings and connected to a transmitter or control unit. An airtight metal chamber rosette, equivalent in capacity to a predetermined length of tubing, can also be connected to the air tubing in small areas where it is not practical to install the tubing. These chamber rosettes are installed in closets, under stair spaces, and in small rooms.

Pneumatic tubing is attached at each end to a vented diaphragm assembly with contacts connected to a signaling circuit housed in the transmitter or control unit. The tubing and diaphragm assembly are airtight except for an adjustable air vent. The air inside of the system is normally at atmospheric pressure. Slowly rising temperature produces within the tubing a pressure which is dissipated through the adjustable air vents in the detector—without affecting the diaphragm enough to send a signal. If the temperature rises rapidly, pressure develops at a rate greater than that for which the vent is adjusted. The diaphragm then moves and produces a signal at the pressure value for which it is adjusted.

Pneumatic tube transmitters and control units are made with either coded or noncoded contacts, and operate solely as a result of rate-of-rise of the temperature and have no temperature rating.

A widely accepted means for automatic detection of fire and extinguishing system operation is the pneumatic system. This system is of the spot type but operates basically the same as the pneumatic tube detector.

Heat-actuated devices (HADs), which are hollow metal air chambers without moving parts, are located close to the hazard involved. Air inclosed in the HADs builds up pressure as temperature increases. This air pressure is transferred by means of copper tubing to a diaphragm inclosed in release box located remotely from the HADs. Intervening between the HADs and the diaphragm is a compensating vent which relieves small fluctuations in pressure, but impedes the escape of any rapid pressure buildup, which would be caused by a fire. If the increased pressure applied to the diaphragm is not relieved, the diaphragm will move, bellows-like, to a point where a lever/weight mechanism or electric switch is actuated, setting the fire protection equipment into operation. The transfer of pressure and actuation of the system is virtually instantaneous, and one release mechanism will monitor many HAD units. The system is not dependent upon electrical power, for it is activated by the energy created from a fire. Rate-of-rise systems can be designed to operate in the event of rupture of the thermo-pneumatic system as well as to an increase in pressure.

Combined fixed-temperature and rate-of-rise. The combined fixed-temperature and rate-of-rise thermostat operates at a definite temperature regardless of the rate-of-rise of temperature. In addition, it has a feature enabling it to operate sooner if there is a rapid rise of temperature. For the fixed-temperature feature, the thermostat closes the circuit either by the fusing of a metal-alloy part or by the movement of a bimetallic part. For the rate-of-rise feature, the circuit is closed either by differential expansion of bimetallic parts or by expansion of heated air in a vent chamber. Now that you have an idea of how the combined thermostat works, let's take a closer look at its internal parts.

When a fire occurs, air temperatures rise rapidly, especially at the ceiling of an inclosure. This rapid rise of temperature, 15° to 20° or more per minute, affects the rate-of-rise portion of the automatic heat detector unit. The air in the chamber is expanded and reacts against a thin flexible metal diaphragm which moves the spring to close an electrical circuit with the screw.

A communicating passage leads from the chamber to the atmosphere in which there is a calibrated vent. This vent is calibrated, set, and sealed at the factory to allow, under normal temperature variations, a balanced relationship between the air in the chamber and the outer surrounding atmosphere. This "breathing-action" allows the vent to "ride-through" normal air changes.

Operation by the rate-of-rise principle, while not related to any specific temperature level, is prompt and sharp at approximately 15° to 20° rise per minute. The breathing action of the vent automatically restores the detector unit to a normal status when the abnormal (fire or test) condition subsides or is removed.

Completely independent of the rate-of-rise feature, the fixed-temperature portion makes use of a metallic spring held to an inactive position by temperature-rated fusible alloy. For instance, should the rate-of-rise feature not respond because of the slow rate of temperature increase of smoldering fires, the spring will be released as soon as the heat at the ceiling reaches the fusing temperature of the alloy. This action moves the diaphragm and spring to close the electric circuit with the screw.

When the heat-detector unit is operated by the fixed-temperature feature, the unit cannot be reset; it must be replaced. A unique indicator is provided for such instances. It resembles a small button on the outside of the chamber; the button becomes a hole when the spring is released. The hole is easily detected. The replacement of the heat detector unit is easily done, since it is held by only two small screws.

Special Fire Detectors. In comparison with the number of units of other fire-detection (heat-actuated) equipment, only a limited number of smoke and flame detectors are installed throughout Air Force facilities. Their operation, though of a basic nature, is quite different from that of standard detection equipment. These more sophisticated detectors normally require special circuits to be connected into your communications center—or require special apparatus to directly connect them into the conventional alarm system.

Smoke detectors. Smoke detectors work on the photoelectric cell principle and are used where the type of fire anticipated is expected to generate quantities of smoke in advance of a temperature rise. There are two general types of photoelectric smoke detectors: the spot type and the line type. The spot type is a self-contained unit employing a short beam between the source and the receiver. The main housing of the spot-type smoke detector consists of a chamber with an opening at the top and the bottom. These openings are baffled to cut out light from outside and are protected by screens to prevent foreign particles from entering. Spot-type smoke detectors are used in much the same arrangement as spot-type fire detectors.

At the bottom of the chamber is a small electric light bulb. This bulb furnishes the light required to operate the unit and also acts as a heater for the air inside the chamber. The heated air, being lighter, rises and passes out through the outlet at the top, allowing new cool air to enter at the bottom. Thus the air in the chamber is constantly changing, so that any smoke in the room will find its way into the chamber.

Two photocells are employed; one is in the middle of the chamber top and the other is over to one side. The one in the middle is in the shadow of a small disc; the one on the side is in the direct light path. Thus it receives more light than the one in the middle; and, under this condition, the detector does not respond.

Should smoke enter the unit, however, some of the light in the direct beam will be reflected under the shadow disc to the center photocell, thus increasing the intensity of the light hitting the cell. This will change the ratio of light intensity on the two photocells and will cause the unit to activate the fire alarm circuit.

In the line-type smoke detector, we find that the source and the receiver are placed at extreme sides of the area to be protected. The system detects smoke, automatically shuts down the ventilating system, and sounds a fire alarm. This arrangement might be found in a base theater or public assembly building. The line-type smoke detector could also be used in large electronic or computer rooms where there is a concentration of electrical equipment. In the line-type detectors, smoke passing through the beam reduces its intensity at the receiver and causes a signal to be transmitted. Some types of smoke detectors also incorporate a thermal element to operate at a fixed temperature.

Flame detectors. Flame detectors employ a device sensitive to infrared rays; this is incorporated in series in an electronic fire alarm circuit. Essentially the sensing element has a ceramic disc and two wires terminating flush with one face of the disc and with a coating of lead sulfide over the terminals. The sensing element provides an electrical resistance varying in proportion to the intensity of the infrared radiation to which it is exposed. It has been found that infrared radiation produced by actual flame is modulated in the frequency range from 5 to 30 cycles per second. To screen out infrared radiation from heaters and other normal sources, the electronic circuit has a filter as part of the detector circuit.

The flame detector responds directly to the presence of flame. The detector senses and responds to infrared radiation, flickering between the frequency of 5 and 30 cps. It is not affected by constant light sources, such as sun or incandescent light. The flickering flames must be present for at least 3, 10, or 30 seconds (depending on the detector selected) before the detector responds. Responses to

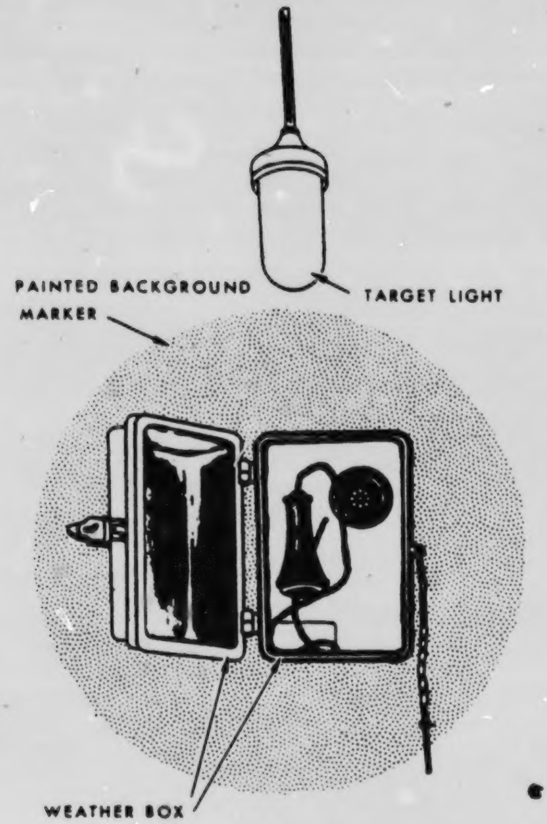


Figure 2-7. Fire phone installation.

constant infrared radiation or to short flickering phenomena are, therefore, excluded.

The flame detector is intended to protect hazards where ignition is almost instantaneous and the anticipated fires will develop quickly with little or no incipient or smoldering stages. These hazard areas would be where there is highly volatile and flammable liquids stored, such as in hangars or indoor fueling capabilities. The flame detector is best suited for direct equipment or process protection and for use on high ceilings.

You can easily check installed flame detectors by using a flame-detector tester—a special flashlight having a built-in transistorized flasher. The flashing light is directed from the floor onto the detector to cause activation.

Fire Phones. Fires may be reported by telephone through the base telephone system or through a special system of fire phones. Normally the installation of fire phones is limited to hazardous and isolated areas. These phones are generally outdoors but may be used to cover large interior areas. Fire phones are connected directly to an alarm switchboard at the fire department communication center. The fire phone, as shown in figure 2-7, is housed in a metal box that is mounted on a pole or external wall of a building. They are placed so that they can be reached from any possible location. These boxes are painted red, with a conspicuous identification background, and they have a red target light mounted over the box so that they can be easily found at night.

To operate the fire phone, lift the receiver to call the fire alarm to the alarm center operator. When the receiver is lifted at the reporting phone, an audible and visual signal is activated on the switchboard position for that circuit. In addition, the activated phone's identification number may be automatically registered on a signal board called an *annunciator*. This number remains visible until the alarm center operator manually clears the annunciator. In this way the positive identification of the calling station is preserved until the emergency call is completed to the alarm center operator's satisfaction.

Exercises (410):

1. What purpose do manual fire alarm boxes, automatic fire detectors, or sprinkler-system attachments serve in connection with automatic alarm system transmitters?

2. An automatic transmitter consists of what four electrical elements?

3. From what source(s) do automatic transmitters receive their power?

4. After an actuating device on a transmitter's remote circuit operates, causing the control mechanism in the transmitter to release and rotate the signal wheel, what happens?

5. When a transmitter has functioned and is restored to normal, it may operate for how many rounds when sending a restoration signal?

6. How does a transmitter warn you of electrical troubles when it, the transmitter, is in the normal standby condition?

7. A transmitter, designed to provide emergency operation when a break in the remote circuit wiring occurs, will send an alarm signal of how many rounds after the trouble round has been given?

8. Evacuation alarms connected to manual fire alarm boxes sound an alarm in what area(s)?

9. Noncoded alarm boxes transmit a signal when the electrical contacts inside the box close due to what action(s)?

10. In the coded alarm box, how is the gear mechanism that rotates the signal wheel driven?

11. Basically, all automatic fire alarm systems incorporate some type of device which reacts to what factor(s) for activation?

12. How are automatic fire detectors classified?

13. The most common fixed-temperature-type fire detectors operate on what principle?

14. How does the snap-action disc thermostat detector operate?

15. When a thermostatic cable has triggered an alarm signal, what has happened within the cable to trigger the alarm?

16. What is the "temperature rating" of a fixed temperature thermostat detector?

17. In the spot-distribution-type rate-of-rise detector, the operation is triggered by what action?

18. In a pneumatic tubing-type detection system, how is the system set to the desired operating pressure?

19. In a detection system consisting of HAD units and all necessary equipment, the system is activated by what means?

20. In a combined fixed-temperature and rate-of-rise detector, which feature closes the circuit by differential expansion of bimetallic parts as one means of operation?

21. In a combined fixed-temperature and rate-of-rise detector, the rate-of-rise portion of the automatic heat detector operates when there is a rapid rise of temperature. What is the temperature rise necessary for operation of this unit?

22. How can you tell when a combined fixed-temperature and rate-of-rise detector needs to be changed due to the operation of the fixed-temperature feature of the detector?

23. Where are smoke detectors used and what principle do they operate on?

24. In a spot-type smoke detector, what causes the unit to activate the fire alarm circuit?

25. When a flame detector operates, it will have been activated by what action?

26. How do you check an installed flame detector to determine if it will function properly?

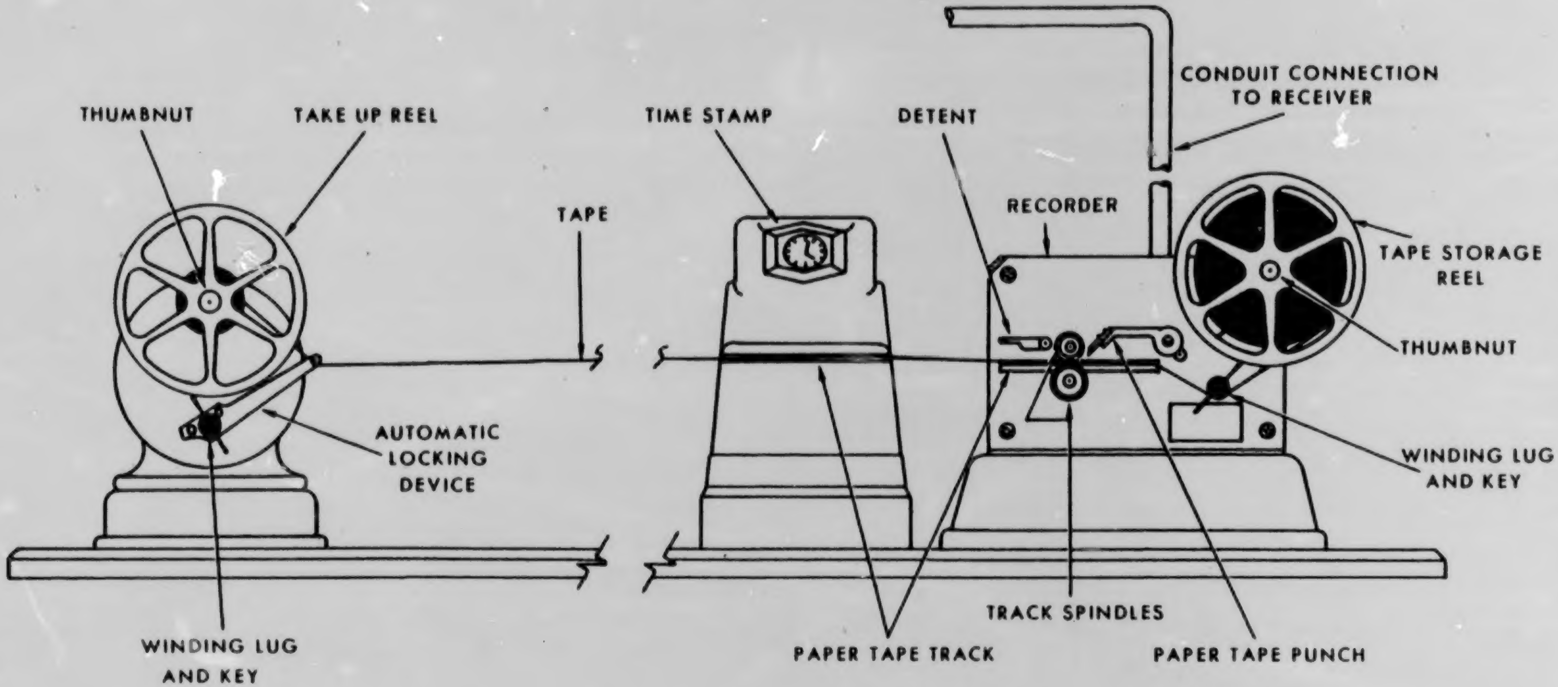

THUMBNUT
TAKE UP REEL
TAPE
AUTOMATIC LOCKING DEVICE
WINDING LUG AND KEY
TIME STAMP
DETENT
CONDUIT CONNECTION TO RECEIVER
RECORDER
TAPE STORAGE REEL
THUMBNUT
WINDING LUG AND KEY
TRACK SPINDLES
PAPER TAPE TRACK
PAPER TAPE PUNCH

Figure 2-8. Paper punch register.

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27. How is positive identification of the calling fire phone station preserved at the alarm center?

411. Complete statements concerning fire alarm receiving and recording equipment.

Receiving and Recording Equipment. The central fire alarm receiving and recording equipment will indicate an alarm by audible or visual means and may also make a permanent record of the signal. This equipment is normally located in the central fire department alarm center. A receiver panel with a register is used for receiving and recording coded signals. The receiver consists of a power supply; the remote circuit wiring; and the electrical control mechanism, with terminals for internal control wiring. First of all, let's analyze the parts of the receiver.

The receiver. The power source for the receiver is 110-volt alternating current (ac). This is called the primary power source for the receiver. However, the power may fail just when a fire alarm signal is being received; if this occurs, the electricity for the receiver must be supplied automatically from another source. One of the most dependable sources of power for emergency purposes is the wet-cell storage battery. A power unit with a battery charger is used to keep the storage battery charged and ready for operation. With batteries and charger installed, you now have a primary and an emergency power source from which the receiver can operate.

The remote circuit wiring connects the central receiver at the alarm center with the alarm-producing devices installed in the buildings on the base. These circuits are normally provided over telephone cable. This system may be electrically "supervised" by the central receiver, which means that if there is a break, or ground, anywhere in the remote circuit which prevents normal receiver operation, you will get an audible or visual trouble signal at the receiver. This is an excellent feature to have built into your system, but it does not certify that your system will never fail or that your system will not have to be tested or maintained.

Internal control wiring and devices at the receiver may serve as the focal point for the alarm system. First, they will receive incoming signals and relay them to the recording device. Also, this system will supervise the remote circuits and power-producing equipment. Sounding devices such as buzzers, diaphragm horns, bells, or gongs are used for indication of various operations at the receiver. These sounding devices are often supplemented with visual devices, to note various operations, with pilot lamps being commonly used. A break in the remote circuit may activate a buzzer and pilot lamp to indicate this trouble. Interruption of ac power will cause another pilot lamp to light and a bell to ring. The audible signal can be silenced by operating a switch, but the pilot lamp remains on until the source of trouble is corrected.

The recorder. A paper-punch register, as shown in figure 2-8, may be used with a coded alarm system. The register has two main parts; the recorder and the takeup reel. The recorder is a combination electrical and mechanical assembly which makes a distinctive cut in a paper tape for each coded signal impulse produced by the receiver. The recorder usually has a spring mechanism which moves the paper tape and is released by the operation of a system control unit. The signal recording is controlled by a signal impulse which operates the paper-puncturing part and releases the mechanism that moves the paper tape. As consecutive signal impulses are recorded, the paper tape moves away from the recorder, exposing, for inspection, the section of tape bearing the signal recordings.

A takeup reel is used in conjunction with the recorder to wind up and store the used part of the paper tape—that which is bearing recorded signals. It usually has a spring-motor mechanism that is released mechanically by a slackening of the paper tape as it moves away from the recorder. There is an automatic locking device to prevent the takeup reel from racing if the paper tape is accidentally broken. The tape may be pulled backwards for inspection after a signal recording has been received.

On many bases the alarm center operator must mark the time and date of all incoming alarm signals on the paper tape. To simplify this, a time-stamp register, also shown in figure 2-8, is sometimes used with the recording device. The time stamp works automatically and marks the date and time on the paper tape when a signal is received. It has an electrically operated time clock mechanism with related printing wheels that mark the tape. When a signal is received, contacts in the recorder operate and the paper tape is pressed against the time printing wheels, thus marking the time of the recording signal.

Some registers mark the paper tape rather than puncture it. A paper-marking register

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makes distinctive marks on a paper tape for each coded signal. It operates like a paper-puncturing register except that the register controls a marking arm, rather than a punch, which presses the paper against an ink ribbon. Different types of paper-tape markings are shown in figure 2-3. A sounding device is also used with the recorder. A gong or horn could be used to sound each time the recorder makes a cut or mark in the paper tape.

With the noncoded system, there is no need for a recording unit, since the signal impulse is continuous. A noncoded receiver or annunciator is nothing more than an electrically controlled signal board that may be used to indicate this noncoded signal. As the noncoded signal is received, it will activate a sounding device. At the same time, on the annunicator, an identification light turns on to indicate the source of the signal.

Exercises (411):
Fill in the blanks in the following statements.

1. The central fire alarm receiving and recording equipment will indicate an alarm by________ or __________ means.
2. The primary power source for the receiver is _____-______ ________ ____________.
3. One of the most dependable sources of power for emergency purposes is the___ ___ _____ _____.
4. The remote circuit wiring connecting the central receiver with the alarm-producing devices is normally provided over___ ___.
5. When an alarm system is so designed to give an audible or visual signal at the receiver when there is a break or ground anywhere in the remote circuit, that system is said to be____________.
6. Supervision of the remote circuit and power producing equipment is accomplished by the ___ _____ and _____ ___ ___.
7. Sounding devices such as______________, _____ _______, ____________, or_______ are used for indication of various operations at the receiver.
8. A paper-punch has two main parts which are the ____________ and the _____ _____.
9. The signal recording is controlled by a_____ ________.
10. The takeup reel has an _____ _____ _____ to prevent the reel from racing if the paper tape is broken.
11. There is no need for a recording unit with the ___________ _______________.

2-3. Fire Suppression Systems

To aid in the determination of what type system should be used in what area, you should know something about the operation of the various types of systems. Sooner or later, you may also be called upon to aid in the inspection and testing of the various installed systems on your base. So to do your job properly, you will need to know the basics of the systems operations. For now let's take a look at how some of the systems operate, and later on in this chapter we will get into the inspection and testing of the various systems.

412. Indicate whether given statements concerning common sprinkler system components are correct. If a statement is invalid, correct it.

Sprinkler systems were designed in their basic form almost 100 years ago. Prevalent fire losses demanded their perfection, and today the automatic sprinkler system is unsurpassed by any other type of fire protection device. Annual records have revealed that in buildings where automatic sprinklers were installed, 96 percent of all fires were controlled or extinguished by these systems. Of the remaining fires that were not controlled in sprinkler-equipped buildings, failure was caused by faulty maintenance or service.

An automatic sprinkler system consists of a series of intricately combined devices arranged so that the system will automatically distribute sufficient quantities of water to either extinguish a fire or to hold it in check until firefighters arrive. Water is fed to sprinklers or open heads through a system of piping. The sprinklers or open heads either extend from exposed pipes or protrude at intervals through the ceiling from hidden pipes. The most common sprinkler head is one that is held together by a fusible metal link. When heat causes the metal to melt, a tightly fitting cap is released from the orifice of the sprinkler head, allowing the water to escape. Most systems are designed to set off an alarm when any single sprinkler head begins to discharge water.

Piping. The sprinkler system piping layout consists of graduated pipe, beginning with the riser, which is the vertical pipe supplying the sprinkler system, in which a one-way check valve is installed. Pipe decreases in size from the riser outward. The pipes connecting the riser to the cross mains are known as the feed mains. The cross main directly services a number of branch lines in which the sprinklers are installed. Most branch lines are extended beyond the end sprinkler head and are capped for flushing purposes. The entire system is supported by hangers or clamps. All pipes should be pitched to help drain the system back toward the inside riser check valve. Approved strainers may be installed in risers and feed mains to prevent clogging of the sprinkler heads with foreign matter.

Sprinkler Heads. Automatic sprinklers, often called *sprinkler heads*, or just *heads*, discharge water after the release of a valve which is activated by some heat-responsive element. This head may be thought of as a fixed-spray nozzle. There are numerous types and designs of sprinkler heads, but we will cover only the more-common types.

These installed heads are kept in a closed position by various devices. Three of the most generally used heads are fusible links, quartz bulbs, and chemical cups, all of which fuse or open in response to heat. The most common head of those mentioned is the fusible link. The solder melts in the fusible link at a predetermined temperature, which varies according to the area to be protected; then the lever arms are released and they spring clear of the head. As the lever arms pop out, they release the seated valve cap, which permits the water to flow. The standard orifice over which the cap is held is approximately one-half inch in diameter. A deflector is attached to the sprinkler frame against which water is thrown to convert it into a spray.

Standard sprinkler heads are designed to discharge water downward as fine droplets in a hemispherical pattern. Upright-type standard sprinklers cannot be inverted for use in the hanging or pendant position. Pendant-type sprinklers should be used in locations where it is impractical to use sprinklers in an upright position. In some cases standard sprinklers may be substituted for old-type heads in an existing system to upgrade the protection. In addition, sprinkler heads may have a cage installed to protect them against mechanical injury.

The old-style heads, some of which are still used, are equipped with deflectors which direct about 60 percent of the discharge to wet a circular area (about 4 to 6 feet in diameter) of the ceiling around the sprinkler. The remainder of the discharge is directed downward in a roughly conical pattern. Old-style sprinklers may be used for replacement in older systems, but should not be used to replace standard heads.

The foam sprinkler heads are designed to distribute air (mechanical) foam or water. The usual arrangement is to discharge air foam for the first 10 minutes, and then follow with water spray. Foam-water sprinklers provide an extra margin of protection, and are applicable to deluge systems where large quantities of flammable liquids may exist.

Special-type sprinkler heads that are lead or wax coated are available and should be installed in areas where chemicals, moisture, or other corrosive vapors exist. Without this special coating, the operational parts of the head will corrode and may become inoperative in a very short time.

A storage cabinet may be installed in the area protected by the sprinkler system to house extra heads and an installation wrench. Normally these cabinets hold a minimum of six heads. It is necessary to use the correct installation wrench and to be very careful when changing heads so as to prevent damage to the head.

Sprinkler heads have different temperature ratings according to the areas in which they are used. Over the cooking area in the mess hall, we would not install the ordinary head as used in the barracks. Nor would we, in a boiler room, use the head installed in the mess hall. The temperature rating is normally stamped on the actuating device. In addition, the sprinkler frame arms may be colored to show the rating.

The following will give you an idea of how sprinkler heads are rated and areas in which they should be used.

Rating	*Color*	*Maximum Ceiling Temp. ° F*	*Operating Temp. ° F*
Ordinary	Uncolored*	100	135 to 170
Intermediate	White**	150	175 to 225
High	Blue	225	250 to 300
Extra High	Red	300	325 to 375
Very Extra High	Green	375	400 to 475
Ultra High	Orange	475	500 to 575

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*The 135° sprinklers of some manufacturers are half black and half white.

**The 175° sprinklers of some manufacturers are yellow.

Control and Operating Valves. In addition to a clapper or alarm valve, which we will discuss later, every sprinkler system should be equipped with a main water control valve and various test and drain valves. Control valves are used to cut off the water supply to the system when heads must be replaced, maintenance must be performed, or operation must be interrupted. These valves are located between the source of water supply and the sprinkler system. These control valves are usually an "indicating" type and are manually operated. An indicating control valve is one that shows at a glance whether it is open or closed. These valves are usually located immediately under either the sprinkler alarm valve, the dry-pipe or deluge valve, or outside of the building near the sprinkler system that it controls. Normally only one control valve is used for each system. If more than one system is supplied by the same underground main, another control valve is required on the main, in addition to the control valves for each system.

Water supply control valves for sprinkler systems should always be gate valves. The mechanism consists of a close-tolerance gate that slides across the waterway in the water main. There are two common types of these indicator control valves that are used in sprinkler systems. One of these valves is an outside screw-and-yoke valve, usually called an O.S. & Y. valve. This valve has a yoke on the outside with a threaded stem which controls the opening and closing of the gate. The threaded portion of the stem is out of the yoke when the valve is open and inside the yoke when the valve is closed.

The other type of control valve used is the post indicator valve, commonly called P.I.V. It is a hollow metal post that is attached to the valve housing. The valve stem is inside of this post; on the stem is a moving target on which the words "OPEN" and "SHUT" are printed. The operating handle is fastened and normally locked to the post. When the valve is open, the word "OPEN" appears in the target glass in the post. When the valve is closed, the word "SHUT" appears at the opening. A wall post indicator valve, commonly called W.P.I.V., is similar to a P.I.V. except that it extends through the wall, with the target and valve operating nut on the outside of the building.

In addition to the main water control valves, sprinkler systems will employ various operating valves such as globe valves, stop (or cock) valves, check valves, and automatic drain valves. Globe valves and stop (or cock) valves are manually operated nonindicating valves. The globe valves are used for draining purposes and for test valves. Stop (or cock) valves are used for draining and for alarm silencing. Check valves are used to limit the water flow to one direction. Automatic drain valves drain off piping when pressure is relieved from the valve. The check and automatic drain valves work on the same principle as do those valves installed in the piping of aerospace vehicle fire trucks.

When control or operating valves are to be closed, the responsible agency should immediately report this condition. The DD Form 1104, Closed Valve Warning, is used to report this condition to the fire department any time a sprinkler system valve is closed. This form is a record for civil engineering craftsmen and also the base fire-protection activity. The upper and lower portions of the warning form are filled out and distributed by the agency closing the valve. The closing agency will attach the upper portion of the DD Form 1104 to the valve and send the lower portion to the fire department. The lower portion of DD Form 1104 should reach the fire department 24 hours before the valve is actually closed.

Exercises (412):

If one of the following statements is correct, mark it True; if it is False, correct it.

___ 1. Uncontrolled fires in sprinkler-equipped buildings are due mainly to the intensity of the fire.

___ 2. The most common sprinkler heads are those which are held together by a fusible metal link.

___ 3. Most sprinkler systems are designed to set off an alarm when any single sprinkler head begins to discharge water.

___ 4. The "riser" in a sprinkler system is the horizontal pipe supplying the system.

___ 5. The feed mains in a sprinkler system are the pipes connecting the cross mains to the risers.

___ 6. The sprinkler heads are installed directly in the cross mains.

___ 7. To help drain the system, all pipes should be pitched back toward the inside riser check valve.

___ 8. The standard orifice for discharge of water from a sprinkler system head is 1½ inches in diameter.

—9. Upright-type standard sprinklers may be inverted for use in the pendant position.

—10. To protect against mechanical injury, sprinkler heads may have a cage installed around them.

—11. When foam sprinkler heads are used, the usual arrangement is to discharge water for 10 minutes, then follow with foam.

—12. Special-type sprinkler heads may be used in areas where unprotected heads could corrode and become inoperative in a very short time.

—13. Besides the normal stamping of the temperature rating on the actuating device, a sprinkler head's frame arms may be colored to show the rating.

—14. In areas where the maximum ceiling temperatures are expected to reach 140° F, an intermediate rated sprinkler head should be used.

—15. The main water control valve for a sprinkler system should be located between the sprinkler system and the source of water supply.

—16. Normally, at least two water control valves are used for each separate sprinkler system.

—17. Water supply control valves for sprinkler systems should always be globe valves.

—18. You can readily tell if an O.S. & Y. valve is open because the threaded stem will be outside of the yoke.

—19. Normally, you will find the operating handle for a P.I.V. fastened by lock to the valve post.

—20. In a sprinkler system piping system, the globe valve(s) are used to limit the water flow to one direction.

—21. When control or operating valves in a sprinkler system are to be closed, the closing agency will send the lower portion of an AF Form 1104 to reach the fire department at least 24 hours before the valve(s) are closed.

413. Given a list of statements concerning various functions/operations of wet-pipe sprinkler system components, match the statement with the equipment item/system it is most closely associated with.

The wet-pipe sprinkler system is full of water and under pressure at all times. This type of system is usually equipped with a valve that is installed in the main riser just inside where the riser enters the building. This valve actuates an alarm when water flows through the system, and it is known as an alarm valve. Incorporated in the alarm valve is a clapper which is simply an automatic one-way check valve with some additional features, and is normally in the CLOSED position. When a sprinkler head operates and causes a flow of water, this clapper opens and permits water to flow to the sprinkler. It also allows the water to flow through the auxiliary valve to a retarding chamber, there to initiate an alarm signal.

The retarding chamber is used where the water is subjected to variable pressures, and is installed between the alarm valve and the alarm signaling equipment. This chamber is a time-delay device and retards the flow of water to the alarm equipment from the alarm valve simply because it must be filled before the water can continue to the alarm equipment. Water drains through the small opening in the bottom of the chamber. If it were not for the retarding chamber, surges or changes in water pressure would cause the clapper in the alarm valve to rise momentarily and to permit water to flow directly to the alarm equipment to cause false alarms.

Although surges or changes in water pressure are counteracted by the retarding chamber, they may, in addition, be offset by the use of an external bypass line. This line permits water to flow around the clapper valve in one direction, from below (supply side) the clapper valve to above it.

With surges of normal intensity in the riser, each successively higher pressure change passes into the system piping through the line of least resistance, which is the external bypass line around the clapper valve rather than through it. There it would then be contained or trapped within the system, through the function of the check valve in the external bypass unit, and accumulating pressure higher than that normally supplying the system. The pressure gages at the alarm valve will record these pressures. In most sprinkler systems, two gages are installed: one is above the clapper and indicates pressure in the system, and one is below the clapper for an independent pressure reading on the supply riser. The accumulation of pressure in the system above the clapper valve, commonly referred to as excess pressure, is an important factor within any variable pressure sprinkler system and is the basis for efficient and trouble-free service. So long as this excess pressure is maintained, the clapper valve will not raise from the seated position under normal conditions. Likewise, so long as this tightly seated position is maintained, water is withheld from the connecting piping to the retarding chamber and on to the signaling equipment.

Operation of the System. When one or more sprinklers open, the flow of water lifts the main clapper off its seat and opens the auxiliary valve. The water pressure in the main riser pushes the clapper to FULL OPEN position and continues on to supply the open sprinklers. Water also enters the auxiliary valve alarm line and continues on to fill the retarding chamber. When the retarding chamber is full, the water activates the pressure switch, sending an electrical alarm signal, and also flows to the water alarm gong to activate it. Once the fire department arrives, if the main riser is accessible, the alarm shutoff valve is closed to stop the alarm signal.

To shut down the system, all that is required is to turn off the main water control valve (O.S. & Y. or P.I.V.), and open the main drain. This stops the flow of water, reducing the water damage from the ruptured sprinkler heads, and begins the draining of the system.

To restore the system to an "in-service" condition, you must first replace the ruptured sprinkler heads. Remember, be sure to use the proper sprinkler head required (temperature wise) for the area to be protected, and always use the proper wrench to prevent crushing or damaging the head. The next step would be to finish sealing off the system by closing the main drain valve and any other valve that may have been opened.

With the system sealed, you should open the main water control valve (O.S. & Y. or P.I.V.) to permit the system to fill with water. The main water control valve should be opened slowly until water flow begins, and then opened at a faster rate to allow the water surge to close and seat the alarm valve clapper. The inspector's test value installed in the far end of the system should be used to bleed off air pressure trapped in the system.

Once the system is wetted, open the alarm shutoff valve. Check the pressure gages above and below the clapper. If the pressure on both gages holds steady and the water alarm is not sounding, the system is holding water, the clapper valve is seated, and the system is operational.

Exercise (413):

1. Match each of the selected statements in column B with the equipment item/system in column A that it is most closely associated with. Write the correct letter in the blank provided. No statement may be used twice, and some statements are not used.

Column A

____ 1. Alarm valve.
____ 2. Sprinkler head.
____ 3. Clapper.
____ 4. Retarding chamber.
____ 5. External by-pass line.
____ 6. Check valve.
____ 7. Pressure gages.
____ 8. Inspector's test valve.
____ 9. Main water control valve.

Column B

a. When restoring the system to an in-service condition, this is first opened slowly and then at a faster rate to seat the alarm valve clapper.
b. When used, this is installed between the alarm valve and alarm signaling equipment.
c. This is installed in the main riser just inside where the riser enters the building.
d. This may be of either the O.S. & Y. or P.I.V. type.
e. When one of these opens, it allows the main clapper valve to be lifted from its seat.
f. When restoring the system to an in-service condition, this is opened to exhaust air pressure trapped in the system.

g. Checking the uppermost of these will indicate to you if there is enough water in the system to properly seat the clapper valve.

h. This is incorporated in the alarm valve and is simply an automatic one-way check valve with some additional features.

i. This permits water to flow from the supply side of the clapper valve to above the clapper valve.

j. This is closed to stop the alarm signal.

k. This is a time-delay device and must be filled before the water can continue to the alarm equipment.

l. This is closed to finish sealing the system when restoring the system to an in-service condition.

m. There must be excessive pressure above this for efficient trouble-free service within any variable pressure sprinkler system.

414. Given a series of incomplete statements concerning dry-pipe and preaction type sprinkler systems, complete the statements by filling in the blanks with the correct word(s) or phrase(s).

Dry-Pipe Systems. You will find that a dry-pipe system is one in which air under pressure replaces water in the sprinkler piping above the clapper. Dry-pipe systems should be used only in buildings where insufficient heat is maintained to keep water from freezing. A dry-pipe valve is a device that keeps water out of the sprinkler piping until fire occurs. When a sprinkler head fuses, allowing the air pressure to escape, the dry-pipe valve clapper opens automatically to permit water to replace the air pressure in the line. Dry-pipe valves are designed so that a small amount of air under pressure above the dry-pipe valve clapper in the sprinkler piping will hold back a much greater amount of water under pressure on the water supply side of the dry-pipe valve clapper. Dry-pipe systems are also equipped with either electric or hydraulic alarm signaling equipment.

Types of dry-pipe valves. The two types of dry-pipe valves that are in use today are the *differential* and the *mechanical*. The differential type has a double-seated check valve or two clappers of unequal size. The upper air seat is considerably larger than the lower (or water) seat, with a surface ratio that is normally five or six to one. The difference in surface area of these two seats determines the difference between water pressure and air pressure that is necessary to "balance" the valve. This difference can be seen in the following:

AIR/WATER DIFFERENTIAL
(DRY-PIPE SPRINKLER)

Air Pressure in PSI		*Water Pressure in PSI*
Min	*Max*	*Max*
15	25	50
20	30	75
25	35	100
30	45	125
35	50	150

This air/water differential serves a two-fold purpose. First, a comparatively small amount of air pressure is required to hold the system operational. Secondly, the less the air pressure throughout the system, the more quickly this air can be expelled by water when a head ruptures, thus reducing the time needed for water to be discharged.

Air pressure in the system should not be permitted to vary beyond the prescribed limits. High air pressure is difficult to maintain, and operation of the valve is considerably delayed if excessively high pressure is used. In systems where pressure from the primary water supply is low and where a fire pump is connected or high-pressure service is available, sufficient air pressure must be maintained to keep the dry-pipe valve from accidentally tripping when the higher water pressure is used.

When air pressure is reduced in the system, the entire differential air plate assembly, water clapper, and water clapper arm rises until the hook pawl is tripped by contacting the operating screw. The water clapper then opens wide, and the differential air plate remains in place.

Where water is subjected to variable pressures, the dry-pipe must counteract these surges. This is done by the rubber diaphragms that allow the entire differential air plate and its assemblies to move up, releasing the excess pressure into the intermediate chamber. Hence the water is drained off through the automatic drip valve.

In the *mechanical* type of dry-pipe valve, the air and water seats may or may not be of the same area. The air seat (air clapper) under the influence of air pressure holds the water seat (water clapper) shut through a system of multiplying levers. Another type of mechanical dry-pipe clapper valve has only one water clapper that is held closed by a system of levers. The levers and clapper are released by a difference in air pressure acting on a diaphragm.

The required air pressure for dry-pipe systems usually ranges between 15 and 50 pounds per square inch. This range, as previously discussed, depends on the type of valve that is used and, in most cases, on the available water pressure.

Air pressure that is needed to service the dry-pipe sprinkler system may be derived from two different sources. This source is either from central air pressure, which is piped throughout the sprinkled area and also used for industrial purposes, or unit air pressure that is supplied from a compressor and tank and is used exclusively for the sprinkler system. Both pressure system components operate automatically to maintain the required air pressure for the dry-pipe system. With a central air pressure supply, a pressure regulator is required to reduce and maintain the pressure needed. With unit air pressure, the same type of pressure regulator may be used with a compressor and supply tank. In addition, a pressure switch is located in the air line between the regulator and the tank to start the compressor when needed to replenish the supply tank. The pressure regulator may employ a bypass line to provide for quick filling or refilling of the system to normal pressure.

In a large dry-pipe system, several minutes could be lost while the water is expelling the air from the system, once water begins to flow. Established are rules that normally require a quick-opening device to be installed in systems that exceed 400 sprinkler heads or in systems that have a pipe system capacity of over 500 gallons. There are two types of quick-opening devices. They are known as (1) *accelerators* and (2) *exhausters*. The accelerator unbalances the differential in the dry-pipe valve, causing it to trip more quickly, whereas the exhauster quickly expels air from the system. When a sprinkler head in the accelerator type is fused, and air pressure in the system drops a few psi—usually 1 or 2 pounds, a diaphragm in the accelerator becomes unbalanced. This unbalanced condition causes a valve to open, and this permits the air pressure in the system to enter the intermediate chamber of the dry-pipe valve. As soon as air is equalized on both sides of the air clapper (normally 10 to 15 seconds), the valve is automatically tripped by water pressure. In the exhauster type, the fusing of a sprinkler head causes a diaphragm to open a larger valve. This action permits air pressure to escape quickly to the outside through this valve and allows the dry-pipe valve to trip.

Both of these devices are complicated mechanisms, and they demand proper care and maintenance. They should be tested at least once each year by a competent inspector. Even if the quick-opening devices do not operate, the dry-pipe valve will still operate, although it will take longer to exhaust the air from the system.

Operation of the System. When one or more sprinklers open, the air pressure is vented through the open heads from the system, thus upsetting the differential within the dry-pipe valve. At this time an accelerator or exhauster will be an aid in the venting process of the system. As the differential is upset, the riser water pressure raises the clapper assembly and mechanically unlocks the clapper, which rides up into the wide-open-and-locked position. The water then continues on to the open sprinklers. As the water fills the upper chamber of the dry-pipe valve, it also enters the intermediate chamber, where it forces the drip-check valve closed and then flows into the alarm line to activate the alarm equipment. Upon arrival of the fire department, if the main riser is accessible, the alarm line shutoff valve is closed to stop the alarm signal.

To shut down the system, close the main water control valve (O.S. & Y. or P.I.V.) and open the main drain. As with the wet-pipe system, this action stops the flow of water, reduces the water damage from the ruptured heads, and begins the draining of the system. The air supply for the system should now be shut off. It may also be necessary at this time to drain any low points in the system, such as the alarm line and the alarm bypass test line—depending on piping arrangement—by opening these valves. Also, examine the drip-check valve to make sure it has opened and drained when pressure was reduced.

To place the system back in service, you must first install new heads in the affected piping area. Again be sure to install the proper sprinkler heads required for the area being protected, using the appropriate installation wrench. If the system incorporates an accelerator or exhauster, it must be reset at this time.

The next step is to reset the dry-pipe valve, and this must be done by hand. Remove the dry-pipe valve hand hold cover, using the special service wrench, to expose the interior of the valve. The clapper should be upright and held in position by a latch on the back of the valve. Trip the latch and pull the clapper down for inspection. The seats and clapper facing should be thoroughly washed and cleaned, if necessary, before the system is again ready for service. An accumulation of dirt is likely to damage them and cause leakage. When the clapper is clean, push it down to the closed position and insert the wrench handle through the handhold and locking ring, lifting up on the wrench handle to reset the clapper. Be careful not to expose your hands in the dry-pipe valve when the clapper is reset, as it may slip and spring to the OPEN position with much force.

Once the clapper valve is seated, the main drain and any other drain valves should be closed to seal the system. Open the priming water level test valve and add priming water to the top of the alarm valve until it appears at the test valve. Then close the test valve and the handhold cover, and bolt tight.

If a priming line and reservoir is installed on the system, close the handhole cover before priming the dry-pipe valve. Then open the priming water level test valve and reservoir line. Prime the dry-pipe valve by admitting water through the priming chamber until it appears at the test valve. Shut both valves when priming is completed.

On systems that do not require priming waters, seal the system, and turn on the system air pressure. When the air pressure is back to normal, the main water control valve should be opened slowly. This will complete the operation and restore the system to a ready condition. Make sure that no leakage occurs through the automatic drip valve. Leakage indicates that either the air or water clapper of the dry-pipe valve is not seated properly. They should be cleaned again, and the valve be reset.

Preaction Systems. The preaction sprinkler system is basically a dry-pipe system with a slight modification which converts the dry-pipe system to a wet-pipe system prior to the opening of any sprinklers. In this system, automatic fire detectors close a circuit which operates a release located in the system actuation unit. This release opens a valve in the preaction attachment and permits water from below the valve clapper to enter the intermediate chamber of the dry-pipe valve. This offsets the differential and trips the valve, thus changing the system to wet-pipe, with water ready when the sprinkler heads fuse. When this change occurs, the alarm system may sound a warning prior to the opening of the sprinkler head.

The preaction system has many advantages. It is always a thoroughly reliable dry-pipe system. The preaction attachment in no way interferes with the function of the dry-pipe valve. There is no accelerator or exhauster required to expel the air in order to hasten the water flow, and water has replaced or compressed what air is in the piping prior to the operation of the sprinkler. Also, there is no necessity to change the preaction system from dry- to wet-pipe system during the summer months, or to flush the sprinkler piping to remove the accumulation of sediment resulting from repeated changes from wet to dry.

Exercises (414):

Fill in the blanks in the following statements.

1. When required in buildings where insufficient heat is maintained to keep water from freezing, you will normally find ________ - ________ sprinkler systems.
2. The device that keeps water out of the piping, in the above mentioned type system, until fire occurrs is a ______ - ___ ___.
3. Dry-pipe systems are equipped with either ____________ or ________ alarm signaling equipment.
4. A double-seated check valve or two clappers of unequal size are incorporated in the ______________ type dry-pipe valve.
5. When a dry-pipe sprinkler system is being used and the water supply for the system has a maximum pressure of 125 psi, the air pressure in the sprinkler system itself should be a minimum of ______ psi and a maximum of ______ psi.
6. In a dry-pipe system, high air pressure is difficult to maintain and the operation of the valve is ____________ if excessively high pressure is used.
7. The dry-pipe valve must counteract surges in water pressure. This is done by the ____ __________ allowing the entire ______ ______ ______ and its assemblies to move up, releasing the excess pressure.
8. When excessive water pressure is released in a dry-pipe valve, it is released into the ___ ________ ________ and the water is drained off through the _____ _____ _____.
9. The air clapper, under the influence of air pressure, holds the water clapper shut through a system of multiplying levers in the ________-________ type of dry-pipe valve.
10. In a mechanical type dry-pipe valve, the levers and clapper are released by a difference in ________ pressure acting on a ____________.
11. The required air pressure for a dry-pipe system depends upon the _____ ___ _____

that is used and, in most cases, the ____ ____ pressure.

12. The two different sources of air pressure for the dry-pipe system are the ________ air pressure system, or the ________ air pressure system.
13. Normally a ________ - ______ ______ is installed in dry-pipe sprinkler systems that have over ________ sprinkler heads.
14. The quick-opening devices which cause dry-pipe valves to trip more quickly because of an unbalance of the differential in the dry-pipe valves are known as ______, while those that quickly expel air from the system are known as ____________.
15. Usually, when an accelerator is used in a dry-pipe system, it will cause an unbalanced diaphragm when the air pressure drops ____________ or ______ pounds in the system.
16. When an exhauster is used in a dry-pipe system, a diaphragm opens a larger valve which permits air pressure to escape more quickly, this action is the result of the ____ of a ________ ____________.
17. When one or more sprinkler heads open and air is vented from the system, the clapper assembly is raised and mechanically unlocked by the ______ ______ ______.
18. As the water fills the upper chamber of the dry-pipe valve, it also enters the intermediate chamber, where it forces the ______ – ________ valve ______ and then flows into the ______ ________ to activate the ________ ________.
19. When incorporated, an accelerator or exhauster must be reset ________ the ________ - ____ ____ is reset.
20. The dry-pipe valve must be reset by ____.
21. An accumulation of dirt on the seats and facing of a clapper is likely to ________ ____ ____ ________ ____________
22. After you have cleaned the clapper valve and pushed in down to the CLOSED position, you should insert the ______ ____ through the handhole and ________ ____ and ________ ________ on the wrench handle to reset the clapper.
23. If a primer line and reservoir is installed on the system, the handhole cover should be ________ ________ priming the dry-pipe valve.
24. Leakage through the ______ ______ ____ indicates that either the air or water clapper of the dry-pipe valve is not ______ ____________.
25. The preaction system is basically a ______ ____ - ______ system with a slight modification which converts it to a ______ ____ - ________ system ______ to the opening of any sprinklers.
26. In a preaction system, the release which opens the valve to permit water to enter the intermediate chamber of the dry-pipe valve is operated by closing a circuit which is actuated by ______ ______ ______.
27. One of the advantages of the preaction system is that it does not require an ______ ________ or ________ to expel the air.
28. In a preaction system, prior to the operation of a sprinkler, the water has ____ or ____________ what air there is in the system.

415. Indicate whether given statements concerning deluge sprinkler systems are correct. If a statement is invalid, correct it.

A deluge system employs open sprinkler heads controlled by a deluge valve. The purpose of a deluge system is to wet down the area in which a fire originates by discharging water simultaneously from all open heads in the system. This system is normally used in extra-hazardous processing areas where there is a danger of flash fires or fires of an explosive nature that could cover a considerable area with resulting high temperatures, particularly where abnormally high head room exists. Many modern aircraft hangars are equipped with an automatic deluge system, which may be combined with another type of automatic sprinkler system. A system using partly open and partly closed heads is considered a variation of the deluge system.

An aircraft hangar should be constructed of noncombustible material. Noncombustible construction, however, is not enough in itself to prevent conflagrations which are caused by gasoline and other vapors present in hangars. In such situations an automatic deluge system is necessary for fire safety.

The ideal arrangement consists of an overhead deluge system arranged so that a series of open heads will discharge the extinguishing agent simultaneously over a given area where aircraft are parked, and a closed-head sprinkler system which will discharge the extinguishing agent individually in other areas, such as the hangar wings, usually designated as shop and office space. These automatic systems require great water volume and pressure.

This type of sprinkler system differs from the system previously discussed in the following ways:

- Sprinkler heads are the open type.

- Number of heads per system is somewhat limited.
- The deluge valve is of a special type.
- The system is operated by independent detecting devices.
- The system may be operated manually.

Automatic activation of the deluge system may be controlled by fire, heat, or smoke-detecting devices. Automatic operation of the system is normally accomplished by means of heat-actuated devices (HADs) uniformly distributed over the ceiling. The operation of one or more of the HADs actuates the deluge valve, admitting water to the overhead system. The automatic electrical activation of the system operates basically in the same manner as the pneumatic devices. Hydraulic operation of the system is normally employed for manual use. This does nothing more than destroy the deluge valve differential when a hand valve is opened, thus activating the system.

Operation of the System. When the system is actuated by the automatic detection system or a manual station, the water pressure in the upper chamber is immediately lowered to almost zero, thus destroying the differential between the upper and lower chambers. This pressure drop will be indicated on the pressure gage for the upper chamber. The pressure in the lower chamber then forces the clapper valve upward, allowing water to enter a third (or side) chamber and also to continue on into the system piping and sprinkler heads. Some of the water entering the third chamber will flow through the indicator valve and piping to activate the alarm equipment. Upon arrival of the fire department, if the main riser is accessible, the alarm line indicator valve is shut off to stop the alarm signal.

To shut down the system, close the main water control valve (O.S. & Y. or P.I.V.) and open the auxiliary drain valve. As with the other sprinkler systems we have covered, this stops the flow of water, reduces the water damage, and begins the draining of the system.

To place the system back in service, first check all the system activating devices that have been subjected to fire to make sure that the devices did not fuse or suffer physical damage. Also close the manual trip valves if necessary. Next, open the priming valve to prime the upper chamber. The system pressure gage should register the normal static pressure when the upper chamber is primed. Close the priming valve and open the main water control valve. The gages for the upper and lower chambers should now register the same pressure reading. Close the auxiliary drain valve and check the indicator valve to be sure it is in the ON position, so that the alarm equipment is back in service. If no leakage has occurred, if both pressure gages hold steady, and no water is escaping through drains or drain cups, the system is back in service.

Exercises (415):

If one of the following statements is correct, mark it True; if it is False, correct it.

___1. Deluge sprinkler systems are normally used in extra-hazardous processing areas where there is a danger of flash fire, particularly where normal head room exists.

___2. A variation of the deluge system is a system using partly open and partly closed heads.

___3. An automatic deluge system is necessary in a noncombustible aircraft hangar for fire safety.

___4. The automatic deluge systems require great water volume at low pressure.

___5. The deluge valve of a deluge sprinkler system is of a common type and the system may be operated manually.

___6. Fire, heat, or smoke-detecting devices may be used as controls for the automatic activation of a deluge system.

___7. The deluge valve actuates, admitting water to the overhead system, only when two or more of the HADs operate.

___8. A hand valve is opened to destroy the deluge valve differential, thus activating the system, in hydraulic operation of the system.

___9. When the deluge system is activated by a manual station, the air pressure in the upper chamber is immediately lowered to almost zero, thus destroying the differential between the upper and lower chambers.

__10. The alarm equipment in a deluge system is activated when some of the water entering the side chamber flows through the indicator valve and piping.

__11. As with the other types of sprinkler systems covered thus far, the deluge sprinkler systems also have a main water control valve of the O.S. & Y. or P.I.V. type.

__12. To put a deluge system back into service, it is not necessary to replace all heads which have discharged water.

__13. The gages for the upper and lower chambers of the deluge valve should register a 10 to 15 psi differential.

__14. After the auxiliary drain valve is closed, you should check the indicator valve to be sure it is in the OFF position.

416. From a list of statements concerning special installed systems, identify the true statements and explain why the others are not correct.

There are several specialized extinguishing systems that you may encounter in your fire protection work. Two of these are the carbon dioxide and foam-installed systems. These systems are called special because they are used in areas where unusual conditions require an installed system other than one using water.

Carbon Dioxide Systems. Carbon dioxide (CO_2) systems can extinguish fires involving flammable liquids in open or closed containers, rooms, ovens, dryers, and other inclosures where carbon dioxide gas may spread through an area. Normally a CO_2 system is used where protection by water or other means may be ineffective. These systems are adapted, principally, to hazardous areas such as engine test cells, dip tanks using flammable liquids, solvent tanks, and electrical installations.

You should already be familiar with the basic operation of these systems, for they are nothing more than adaptations of the carbon dioxide portable fire extinguishers. There are two minor differences between these systems and the ones you have already encountered. First, these systems are "fixed" and cannot be moved. Second, many of these fixed systems will discharge carbon dioxide automatically. Aside from these two minor differences, you will find that fixed carbon dioxide systems are basically the same as portable carbon dioxide units.

These fixed systems employ two types of storage for carbon dioxide. Low-pressure storage consists of refrigerated tanks holding liquid carbon dioxide, at 300 psi at 0° F. The storage tanks range in size from 500 pounds to 125 tons. In high-pressure storage, liquid carbon dioxide is stored in 50- and 100-pound metal cylinders. The number of cylinders varies with the size of the area being protected and the method of carbon dioxide application. These cylinders contain CO_2 at 850 psi at 70° F. Either of the two types may be used.

The entire layout of the fixed carbon dioxide system is very similar to the dry-pipe or deluge sprinkler system. In both the high- and low-pressure carbon dioxide systems, the storage units are connected into a manifold which branches out to fixed piping that connects to the discharge orifices or nozzles. Both systems may be operated either automatically or manually. Automatic operation is normally controlled by quick-operating detection devices. Automatically operated systems should have an independent means for manual operation.

Four methods used in the application of carbon dioxide with fixed systems are briefly described as follow:

a. Total Flooding. This consists of diluting the entire atmosphere of an inclosure with carbon dioxide until the fire is extinguished.

b. Local Application. In this method the fire is extinguished by discharging carbon dioxide directly into the fire or on the burning material.

c. Extended Discharge. This method of application floods the area initially with carbon dioxide and then releases additional amounts to maintain the desired level of concentration.

d. Hand Hose Lines. Handlines are used manually as first-aid extinguishing equipment within a limited area. These handlines may also be used to apply carbon dioxide in any of the other above methods.

Operation of the system. The major components that comprise this system are the storage unit, the piping and nozzles, the detection devices, and the actuation device.

When the actuation control unit is signaled by the automatic detection devices or manual station, it functions in two ways. First, it will sound the evacuation alarm to alert the building occupants and the fire department—that is, if it is connected into the central fire department communications section. Second, after a predetermined time limit, the actuation device will release the carbon dioxide gas. Because of the smothering characteristics of the CO_2 gas, this delayed discharge will allow time for the personnel to evacuate the area. The carbon dioxide gas passing through the piping will trip the pressure switches, closing the windows and fire door, and shutting down the vent fan. This carbon dioxide gas passes out the fixed nozzles to extinguish the fire or inert the area.

Foam-Water Systems. The foam-water extinguishing system provides much the same general protection as does the standard deluge sprinkler system. Of course the foam-water system has a decided advantage in areas where the hazards involve flammable liquids. In aircraft hangars, where adequate floor drainage cannot be provided, the foam-water system has an advantage over a deluge system. This advantage comes from the fact of foam's smothering action for class B fires (which can normally be expected in aircraft hangars). The major advantages of this system are the blanketing suppression of flammable liquid fires, better protection under and around obstructions, and effective blanketing of liquid spills to eliminate ignition.

These foam-water system installations consist of foam-producing units attached to permanently piped systems discharging through nozzles and arranged to operate automatically or manually. There are various methods and many system arrangements for producing chemical or mechanical foam for installed systems protecting dip tanks and large storage tanks containing volatiles and other special hazards, but we will discuss only the more common type.

The entire foam-water system may be divided into two parts: (1) the water system, which is the same as the sprinkler systems with water supply line and O. S. and Y valve you have been studying, and (2) the foam system. Components of the mechanical foam system used with the sprinkler system consist of a foam liquid storage tank, a metering valve, pump, strainer, check valve, globe valves, piping, and actuation units. Most foam systems are deluge types, foam being permanently piped into the system and use being made of special, open-type, combination foam/water deluge sprinkler heads. The plumbing arrangement and theory of operation is very similar to the fixed foam-water mobile systems used on crash trucks.

Operation of the system. In the operation of the system, the HADs detect the fire and then signal the actuation units on the deluge valves. The deluge valve opens, permitting water to enter the system. At the same time, the companion deluge valve opens, and the electric motor and foam pump start to introduce foam liquid into the system. The water/foam solution in the piping continues on to the sprinkler heads, where air is introduced into the solution, producing the proper foam extinguishing agent.

After the fire is out, the system is shut down and drained. The foam storage tanks are refilled through the foam filler line. The system can be flushed to remove foam liquid and prevent corrosion by attaching a water line to the water flush line and flushing the system through the open heads or through the flush line. Once the foam system is filled and flushed, the system can be restored to normal. To do this, reset the actuation units and the deluge valves.

The procedures for testing and inspecting the fixed foam extinguishing system will be the same as the other sprinkler systems we have covered.

Exercises (416):

Identify each True statement and explain why the others are False.

1. Specialized extinguishing systems that are used in areas where unusual conditions require an installed system other than one using water are called special installed systems.
2. Installed carbon dioxide systems are basically the same as portable carbon dioxide units, except that they are "fixed" and cannot be moved.
3. The only source of CO_2 for an installed system is stored at 850 psi at 70° F.
4. When a high-pressure storage system is used for an installed system, the number of storage cylinders required will vary with the size of the area being protected and the method of agent application.
5. Automatically operated carbon dioxide systems should be operated only by quick-operating detection devices.
6. When the extended discharge method of application is used, the area under consideration is initially flooded with carbon dioxide and then additional amounts of carbon dioxide are released to maintain the desired level of concentration.
7. Hand hose lines are used just for the local application of carbon dioxide.
8. An installed CO_2 system has a time delay feature between the alarm sounding and agent discharge to allow personnel time to evacuate the area to be flooded with CO_2.

9. The pressure switches in the carbon dioxide system piping are used to regulate the rate of agent discharge.

10. Foam-water extinguishing systems have a decided advantage in areas where the hazards involve electrical equipment.

11. Most foam systems use the same type sprinkler heads as those used in wet-pipe sprinkler systems.

12. Air is introduced into the water-foam solution at the sprinkler heads producing the proper foam extinguishing agent.

13. To remove foam liquid from the piping and to prevent corrosion, flush the foam-water system by attaching a water line to the water flush line and flush the system through the open heads or through the flush line.

417. Indicate whether given statements concerning standpipe systems are correct. If a statement is invalid, correct it.

Standpipe Systems. A well-designed, properly equipped, and well-maintained standpipe system, though lacking the automatic feature of a sprinkler system, is second only to sprinkler systems in the order of devices designed for efficient fire protection. The standpipe system provides effective fire streams in the upper stories of high buildings in the shortest possible time. It may be designed for use by fire departments or for first-aid fire protection by occupants, and should be ready for use at all times.

Standpipe systems consist of an arrangement of pipes usually varying from 1½ inches to 4 inches in diameter. These pipes form a network extending to the vertical and horizontal extremes of a structure. At strategic points there are outlets connected to hoses and nozzles for the purpose of fighting fire quickly and efficiently. The piping layout for a standpipe system is very similar to that of the sprinkler systems. The base main is tapped by a branch main which connects with the main risers that supply the hose stations. Normally the branch main will have siamese pumper connections installed and check valves to limit the water flow.

Standpipe systems may be divided into two general classes. One system consists of small pipes intended for use by the laymen or occupants of the building. The hose leading from the outlet is generally made of thin, flat linen and is capable of being stored or racked in a small space. The other system consists of large pipes intended for use by fire departments. Large standpipe systems are usually installed in extensive buildings where fire outbreaks and fire propagation are more serious. These two general systems may be combined for use either by building occupants or by the fire department. Where there is a large standpipe system intended for use by fire departments, it may become necessary to increase the volume or pressure by auxiliary means, such as an installed fire pump or by using structural pumpers.

Fire department personnel will normally bring their own fire hose into a building for use with a standpipe system, rather than depend upon the linen hose within the building. Any point in the building should be reached if the standpipe outlets are properly distributed and the correct outlet is selected. Often a 2½-inch standpipe outlet is adapted to a 1½-inch hose by means of a reducer coupling.

Minimum water supplies for first-aid fire protection standpipes should be 100 gallons per minute for at least 30 minutes, with a residual pressure of 65 psi at the topmost outlet. Additional water supply and pressure should be determined by requirements as directed by individual conditions.

Exercises (417):

If one of the following statements is correct, mark it True; if it is invalid, correct it.

___ 1. A properly equipped, well designed and maintained standpipe system is second only to sprinkler systems in the order of devices designed for efficient fire protection.

___ 2. Standpipe systems may be designed for use as first-aid fire protection by occupants or for use by fire departments.

___ 3. Standpipe systems consist of an arrangement of pipes usually varying in size from 1½ inches to 4 inches in diameter; these pipes form a network extending to the innermost parts of a structure.

___ 4. Normally, the branch main of a standpipe system will have gated wye pumper connections installed and check valves to limit the flow of the water.

___ 5. One of the systems (which standpipe systems may generally be divided into) consists of large pipes intended for use by the layman or occupants of the building.

___ 6. Where a large standpipe system, intended for use by fire departments, is installed, it may become necessary to increase the volume or pressure of the water supply by auxiliary means such as an installed fire pump or by using pumpers.

___ 7. The minimum water supply for a first-aid standpipe system should be 100 gpm for 1 hour with at least 65 pounds of residual pressure at the topmost outlet.

2-4. Inspection and Service Testing

Careful inspection, service testing, and maintenance are essential if a fire alarm or suppression system is to perform reliably. To insure that proper remedial action is taken without delay, the system inspectors and operators at fire stations and other points where signals are transmitted, received, and recorded must understand the system thoroughly enough to interpret all signals correctly and to detect faulty operations immediately.

As we mentioned previously, fire alarm and suppression systems vary in make, equipment, and design. Methods of inspection, testing, and maintenance must vary accordingly. The manufacturer's descriptive material and instructions regarding equipment and circuit arrangement of the installed system is the best aid in understanding the details of the system performance and possible causes of trouble. Therefore this section will not attempt to give all the details of inspections and maintenance for every type of fire alarm or suppression equipment, but just the main points.

418. Complete statements concerning the inspection and service testing of receiving and recording equipment.

Receiving and Recording Equipment. There are three main areas with which you are concerned in your duties of inspection, service testing, and maintenance of receiving and recording equipment: (1) the receiver, (2) the battery charger, and (3) the recorder.

Receiver. You must check and report immediately any circuit fault condition indicate by the receiver's trouble-signal or pilot lamp. Be sure to check the meter readings as required to insure that the receiver is working properly.

Keep the receiver free from dust, dirt, and similar foreign material. Most unit doors are equipped with a gasket for sealing purposes. Also, most of the relays are protected with a dust cover. It is *imperative* that the unit be kept free of dust and dirt that could foul relays or damage other equipment. When cleaning, avoid just shifting the dust to electrical contacts and other operating parts. A vacuum cleaner is recommended.

Inspect all remote circuit wiring for proper support, and for wear, punctures, cracks, and other defects which may injure the insulation. Where circuits are enclosed in conduit, inspect the conduit for solid connections and proper support. Keep all sounding devices (bells, gongs, buzzers, etc.) free from paint and dirt, which may interfere with their operation.

Keep the receiver clear of objects which are not part of it, and store no objects on or in the receiver cabinet. We mention this because moving parts may be fouled or electrical shorts may occur because of the "cluttered up" interior of the receiver. Many units with lockable doors have ample room inside, which makes them very desirable places to store bench stock supplies, such as extra relays, rectifiers, light bulbs, and test equipment.

Operate the system receiver to determine the performance of all circuits and related equipment. Do this in connection with operating tests for system transmitting and actuating devices with which the receiver is connected.

Battery charger. Check the meter reading on the power unit to insure that the battery charger is operating properly. Test the power unit by interrupting the 110-volt ac so as to insure that the batteries will work and that the unit will switch power. Operate the receiver at this time to complete the test. In conjunction with this test, make sure that the trouble signal and pilot lamps work.

Keep the battery electrolyte above the low-level mark (top of plate separators). Do not fill above the high-level mark as indicated on the battery. Do not use acid to fill the battery, be sure to use only pure distilled water which has been kept in hard rubber or glass containers. Keeping the battery properly filled is one of the most important points in battery maintenance. Neutralize any spilled electrolyte with ammonia or washing-soda solution. Be sure to keep open flames away from the battery, because they may cause the gases given off by the battery to explode. The specific gravity of electrolyte indicates the condition of the battery. This may also be indicated by float balls installed in the battery. But measure and record the specific gravity of each cell periodically. Keep the specific gravity of each cell within the limits recommended by the manufacturer. If the specific gravity in a cell falls below the value recommended by the manufacturer, the cell may need an extra

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charge; if so, follow the manufacturer's instructions when charging it to bring the specific gravity up to normal. This may be done without removing the battery from the system if a fast-charge unit is built into your charger. Keep the battery top and rectifier parts free from dust and other foreign materials. Clean the contacting surfaces to provide low-resistance bonding between clamped (not welded) connections at each battery terminal post.

Recording equipment. Check the recorder and takeup reel for physical damage. Rewind the spring-driven mechanism if necessary, but do not use unnecessary force. Keep enough paper tape on the recorder for at least three four-round coded fire alarm signals, and maintain a readily accessible supply of spare tapes. A poor quality of paper or unevenness in the texture will soon put a register out of commission. To insure long life and good results, it is necessary to have the required special paper of uniform texture and of such quality that it will give off very little paper dust which could clog working parts.

To replace the paper tape, remove the thumbnut and front cover on the storage reel. The paper is then threaded under the paper tape punch, through the spindles and paper tape track of the recorder and time stamp. Remove the thumbnut and front cover on the takeup reel. Then remove the used paper tape roll and replace the front cover and thumbnut. Continue with the new tape; fasten it to the takeup reel and place the automatic locking device over the new tape. Refer to the manufacturer's material that applies to your particular system for further information on this subject. The paper tape should be aligned in the recording device, time stamp, and takeup reel or its equivalent so that it does not break or snarl the tape during signal recording.

Maintain the ink ribbon in a condition that insures legible signal recordings. Move the ribbon of infrequently operated recorders manually to prevent the exposed sections from drying.

Keep the time stamp set for the correct time and date. Check the ribbon for wear and replace it if necessary. Oil all wearing parts regularly to assure proper operation. Keep the type wheels clean at all times.

Keep the recording device clear of objects which are not part of it and make sure that no objects are stored on nor in the enclosure. The recording devices must be kept accessible for servicing and observing signal recordings and must be clear of dust, dirt, and similar foreign material. When cleaning, avoid shifting dust to operating parts.

Operate the recording device to determine the performance of the register. Rewind the recorder and takeup reel when the tests are completed. When practicable, make these tests in connection with operating tests for other equipment of the system. The punch recorder should operate to record the complete number of signal rounds of each system transmitting or actuating device, and should indicate each signal impulses definitely and clearly. The spacing of individual signal impulses should identify each coded signal. No sticking, binding, or other irregularities should occur. Mov[illegible] paper tape away from the recorder so [illegible]t least one complete round of the reco[illegible] signal is visible. The recorder and takeup reel may require oiling occasionally. This will vary according to the manufacturer's requirements and operational use. Use only the best watch oil, and then only sparingly. The time stamp should indicate clearly the time of a signal recording and should not interfere with the movement of the paper tape.

Exercises (418):

Fill in the blanks in the following statements.

1. In your duties of inspection, service testing, and maintenance of alarm receiving and recording equipment, you will be concerned with three main areas, which are the (1)____ ________, (2)________________ ____________, and (3)____________.
2. You must check and report immediately any circuit fault condition indicated by the ______-__________ or ________ __________.
3. To avoid shifting dust to electrical contacts and other operating parts, it is recommended that a ________ __________ be used for cleaning purposes.
4. Where circuits are enclosed in conduit, you should inspect the conduit for __________ ___________ and ____________ __________.
5. You should keep all sounding devices free of __________ and __________ which may interfere with their operation.
6. Operation of the system receiver, to determine the performance of all circuits and related equipment, should be accomplished in connection with _______________ ____________________ for system _______ and ___________ ___________ with which the receiver is connected.
7. To insure that the battery charger is operating properly, you should check the

________ ________ on the ________ ________.

8. To insure that the batteries will work and that the unit will switch power, you should ________ ________ ________-________ ________.
9. To complete the test of the power unit, you should operate the ________ while on battery power.
10. When filling the batteries, you should use only ________ ________ ________; do not use ________.
11. You should use ________ or ________-________ ________ to neutralize any spilled electrolyte.
12. The condition of a battery is indicated by the ________ ________ of the electrolyte.
13. If it is necessary to rewind a spring-driven mechanism of the recording equipment, be careful not to use ________ ________.
14. There should be enough paper tape on the recorder for at least ________ ________-________ ________ fire alarm signals.
15. To remove and replace the paper type on the recording equipment, you must remove the ________ and ________ ________ on both the storage reel and the takeup reel.
16. If the recorder in the alarm center at your fire station is infrequently operated, you should ________ ________ the ink ribbon to insure legible recordings.
17. The recording devices must be kept free of foreign objects and accessible for ________ and ________ ________ ________.
18. You should operate the recording device to determine the performance of the ________.
19. The recorder and takeup reel may require oiling occasionally; this will vary according to the ________ ________ and ________ ________.

419. Point out actions to be taken and the reason for taking a specific action during the inspection and service testing of automatic transmitters.

Automatic Transmitters. Check the meter readings on the transmitter for normal operation. Inspect the transmitter for physical damage and condition. Check the control mechanism and rewind if necessary, but do not use unnecessary force. Refer to figure 2-1 as you study this material covering the transmitter.

As with the equipment we just mentioned, the transmitter cabinet should be kept clean and should not be used for storage purposes. The transmitter should be readily accessible and the access door should be kept tightly closed.

All remote circuit wiring should be inspected for proper support, and for wear, punctures, cracks and other defects which may injure the insulation. Where the circuits are enclosed in conduit, then you must also inspect the conduit for punctures, cracks, solid connections, and proper support. Keep all sounding devices (bells, gongs, buzzers, etc.) free from paint and dirt which may interfere with their operation.

Operate the transmitter to determine its signaling performance. Make this test in conjunction with operating tests for other equipment of the same system. Before conducting any tests, be sure to notify all concerned personnel, such as those in the fire department alarm room as well as those in and around the building.

To test the transmitter, operate the manual actuating device connected to the transmitter circuit. It's a good practice to use a different actuating device for each test period, as inactivity may cause a device to stick or bind. The transmitter should operate for the complete number of alarm-signal rounds for which it is designed. The signaling contacts should cause the assigned coded signal impulses to be recorded on the connected receiver circuit. The coded signaling mechanism should operate reliably and uniformly with no sticking, binding, or other irregularities. If local evacuation alarms are connected to the transmitter, they should be checked during the test. Other equipment that may be started or shutdown during the transmitter operation should be checked and restored to proper operation. If an emergency power supply is installed, test by interrupting 110-volt ac to insure that the batteries will work and that the unit will switch power. After the test, restore the actuating device to normal standby condition, and rewind if necessary.

Transmitters without manual actuating devices will normally have a built-in switch for test purposes. Another alternate method for testing is to shunt (jump) across the remote circuit terminals in the transmitter. You may do this with a short piece of insulated wire with an alligator clip on each end (test lead). The shunt wire connected across the terminals serves the same purpose as the operation of the test switch or actuating device.

To test for open-circuit fault, open either the transmitter power supply by removing the fuse or open the actuating device circuit at the terminals by disconnecting a contact. The transmitter should operate for a one-round trouble signal, but normally the local evacuation alarm should not sound. After the test has been completed, be sure to restore the transmitter to its normal standby condition.

To test for ground-circuit fault, connect the test lead between the transmitter ground terminal and each transmitter actuating device circuit terminal in turn, so that only one of the actuating device circuit terminals is grounded at a time. When the ground fault test lead is applied to any terminal of the transmitter actuating-device circuit, the result should be either no operation of the transmitter or a one-round trouble signal. No alarm signal should result under these ground fault conditions. After the test, restore the transmitter to normal standby condition.

Exercises (419):

1. Why should you operate the transmitter during a service test of the transmitting equipment?

2. What should you do before starting any test of alarm transmitting equipment?

3. How do you normally test the transmitter?

4. When the transmitter is tested, for how many rounds should the transmitter operate?

5. If you should encounter a transmitter without a manual actuating device or built-in test switch, how would you test the transmitter?

6. What will happen during your inspection and/or test of a transmitter if you remove the fuse in the power supply?

7. After you have connected the ground fault test lead to the transmitter ground terminal and you apply the free end of test lead to one of the actuating device circuit terminals, what should happen?

8. What should you do upon completion of your test of a transmitter?

420. Given a series of incomplete statements concerning the inspection and service testing of automatic fire detectors, complete the statements by filling in the correct word(s) and/or phrase(s).

Inspect to see that there are no obstructions which would prevent heated air from reaching the detectors. Such obstructions could be caused by stored materials being piled too high, by temporary partitions, or by mezzanine decks or other unauthorized temporary structures which may shield detectors from heated air. Call such conditions to the attention of persons in charge of the building and note them on inspection records. If necessary, report these deficiencies immediately to the fire chief or his assistant. Check the detectors for proper mounting on supporting surfaces and for physical damage. Replace detectors that are found with paint or with excessive corrosion on them. These inspection tips as presented here are general and are adaptable to both spot- and line-type fire detectors.

Rate-of-Rise Devices. Special equipment is required to test the operation of the rate-of-rise (spot-type) detectors or the rate-of-rise feature in combined fixed-temperature and rate-of-rise detectors. Test equipment required for this test consists of a test heater device and a stop watch. The heater device is a cylinder made of sheet metal with a ceramic disc recessed in the bottom of the cylinder to form a base. The base is tightly fitted and the side of the cylinder is sealed to provide a practically airtight assembly. A porcelain lamp receptacle mounted on the base inside the cylinder holds a 120-volt 60-watt lamp or its equivalent. A flexible supply cord to the lamp receptacle passes through the base. A 2¼-inch-diameter hole in the ring with a tapered edge at the top receives the detector to be tested. A conduit connector on the base is used to provide a lock for a conduit extension handle.

The heating device provides a hot-air bath. When the air bulb of the detector is placed in the adapter ring opening at the top of the heater, it absorbs heat at a rapid rate. This should cause the rate-of-rise feature of the detector to send an alarm signal. The time during which the testing device can be applied without causing operation of the fixed-temperature element of the detector depends upon the marked temperature rating of the detector and the wattage rating of the heat-producing lamp. When using a 60-watt lamp, you can obtain a temperature of approximately 165° *F.* after 1 minute with the detector in place.

Before using the assembled testing device for testing the detectors, connect it to a 120-volt supply for about 15 minutes to preheat the parts of the tester uniformly. Then apply the device to each detector and note the time required for the detector to operate. If possible, keep the testing device connected to the 120-volt supply throughout the tests. If the device must be disconnected between tests, reheat it to approximately the same temperature that was used on the last test. The temperature inside the device must be uniform if it is to give a reliable basis for comparing the response times of different detectors. If several tests are made on one detector, you will get different response-time values unless the following conditions are the same at the start of each test: (1) temperature of the air surrounding the detector, (2) temperature of the detector, and (3) temperature of the testing device.

The rate-of-rise element of each detector should send an alarm signal over the circuit within a time that compares favorably with the response time obtained during preceding tests. Make necessary allowances if the temperatures of surrounding air and detector vary during prolonged tests. When practicable, make this test in conjunction with operating tests for other equipment of the same system.

Heat-actuated devices. Now let's briefly discuss the heat testing of the preaction or deluge system heat-actuated device (HAD). The test heater used for testing the HAD is similar to the tester for rate-of-rise detectors.

Be sure that the test heater is connected to a 100-volt ac outlet. The electric test set must not be used in places where explosion-proof or dust-proof equipment is required. In such places use hot water (175° F or more) in a container which can be placed around the HAD, so that it can be submerged in the hot water.

Close the main water control valve and open the 2-inch drain valve on the riser involved (for the duration of the test only). Place the electric test set or hot water in contact with a HAD, and observe the time in seconds required for tripping of the sprinkler valve. After allowing sufficient time for the pressure in the HAD system to compensate, reset the sprinkler system. Select a HAD connected to each of the other pneumatic circuits and repeat the heat test, resetting the release each time.

Unfortunately we cannot give you any specific times that would accept or reject these two automatic fire detectors. The detectors themselves may vary slightly because of the different manufacturers. However, the biggest obstacles to any standardization are the local conditions and the actual placement of the detectors. In fact, the actuation temperature could vary, even in specific areas in a given building. You have to take into consideration the nearness to heating units, doors, and even long unheated hallways. Sometimes the detector will be readjusted from a winter setting to a summer setting.

Thermostatic cables. Generally there is no way that line-type thermostatic fire detectors can be tested by actual operation, as you would test spot-type detectors, unless manual alarm boxes are installed in the circuit. However, there is a way of testing the thermostatic cable to determine whether or not there are faulty sections in the circuit. You use a thermostatic cable fault locator.

Before the introduction of the fault locator, visual inspection and the use of the ohmmeter were the only ways to check a thermostatic cable. This sometimes made the checking of this cable a long and laborious job. Now, with the use of the fault locator, the job is relatively simple.

The thermostatic cable fault locator is designed to locate inoperative points in thermostatic cable, commonly referred to as *faults*. This compact, light-weight unit is fully transistorized for maximum dependability of operation and for low-power requirements. When they are not in use, all the components should be in the transmitter cabinet. Also, remember that the removal of the plugs from the receiver and transmitter automatically disconnects the batteries.

Faults can be quickly and accurately spotted with this locator. To test a section of thermostatic cable, completely disconnect it from its transmitter or control unit and then couple it to the transmitter cord using the alligator clips. Plug the headphones and the exploring head into the receiver, which may be carried in your pocket. After the headphones are put on, move the exploring head along close to the thermostatic cable, using a piece of

1/2-inch thin-wall conduit tubing as a handle if necessary. As this is being done, you will hear an audiofrequency tone with a "beat" or "pulse." When the signal stops, you will know that you have located a spot fault or an inoperative point.

By examining the cable at this point, you can usually determine the cause of the trouble. If mechanical damage, such as pinching or abrasion, has caused the fault, it will probably be apparent at the exact location found with the detector. If a section has been operated by heat, the portion located will look swollen, or as though the normally sharply defined "twist" is gone. The affected section or point should then be removed and a new section spliced in. Then recheck the cable and, if it is found operative, reconnect it to its control unit and restore the system to its normal standby condition.

Exercises (420):

Fill in the blanks in the following statements.

1. You should inspect the area in which automatic fire detectors are located to insure that there are no obstructions which would prevent ________ ________ from reaching the detectors.
2. Detectors that are found with ________ or ________ ________ on them must be replaced.
3. The special equipment required to test the operation of the spot-type rate-of-rise detectors consists of a ________ ________ ________ and a ________ ________.
4. If you should have to replace the lamp in a rate-of-rise test heating device, you should replace it with a ________-________ ________-________ lamp or ________ ________.
5. The time during which the testing device can be applied to a detector without causing operation of the fixed-temperature element dependents upon the ________ ________ ________ of the detector and the ________ ________ of the heat-producing lamp.
6. After you assemble the testing device (and before using it), you should ________ the parts of the tester ________ by connecting it to a 120-volt power supply for about ________ ________.
7. To achieve a reliable basis for comparing the response times of different detectors, the temperature inside the device must be ________ for all units tested.
8. Besides the temperature of the detector and the testing device, the temperature of the ________ ________ ________ ________ will have a bearing on the response-time values of the rate-of-rise elements.
9. When making an inspection and service test of HADs, you should not use the electric test set in places where ________-________ or ________ ________-________ equipment is required.
10. In areas where the electric test set cannot be used, you should use ________ ________ (at least ________) to conduct the test.
11. Before testing the HADs, you should close the ________ ________ ________ valve and open the ________-________ ________ valve on the riser involved.
12. The biggest obstacle to any standardization of specific times for acceptance or rejection of the rate-of-rise detectors or HADs are the local conditions and the ________ ________ ________ ________.
13. Generally, the only way you can test line-type thermostatic fire detectors by actual operation is if there is/are ________ ________ ________ installed in the circuit.
14. To determine if there are faulty sections in the circuit of the thermostatic cable, you should use a ________ ________ ________ ________.
15. When using the fault locator in testing thermostatic cable, the ________ and ________ ________ are plugged into the receiver.
16. As you move the exploring head of the fault locator along a section of thermostatic cable, you will hear a ________ with a "beat" or "pulse" which will ________ when you have located a spot fault or an ________ ________.
17. If a section of thermostatic cable has been operated by heat, it will look ________, or as though the normally ________ ________ ________ is gone.
18. When a defective section of thermostatic cable has been located, the affected section or point should be ________ and a new ________ ________ ________.
19. After necessary repairs have been made to a thermostatic cable, you should ________ ________ ________ and, if found operative, reconnect it to its ________ ________ and restore the system to its ________ ________ ________.

421. Given a list of statements concerning the inspection and service testing of manual fire alarm boxes, sprinkler-system water flow alarms, and fire phones, match the statement

to the system/subsystem it is most closely associated with.

Manual Fire Alarm Boxes. Inspect the manual boxes, such as those shown in figures 2-4 and 2-5, to make sure access is unobstructed and that the boxes can be easily reached and operated. Keep the box housing tightly closed to prevent entrance of dust. Replace cracked or damaged glass parts. Check door latching parts for serviceable condition, so the door can be opened easily and the operating parts can be reached.

Operate the manual boxes to determine their signaling performance. As previously mentioned, these tests should be made with other equipment in the same system.

Operate the noncoded fire alarm box shown in figure 2-4 by unlocking the cover so it is moved away from the contact-actuating plunger. When the cover is well away, release the switching mechanism to operate its signaling contacts.

Operate the coded fire alarm box shown in figure 2-5 by moving the pull-lever for maximum travel, and by then releasing it. Moving the pull-lever winds the mechanism. When the pull-lever is released, the box mechanism should operate for the complete number of alarm-signal rounds for which it is designed. The coded signaling mechanism should operate reliably and uniformly with no sticking, binding, or other irregularities. The signaling contacts should cause the assigned coded signal impulses to be recorded on the connected control unit circuit both in the normal operating condition and in the emergency signaling condition. After the signal has been completed, the box should be in the normal standby condition.

Sprinkler-System Waterflow Alarms. Inspect the sprinkler-system alarm attachment for ease of servicing. The housing should be tightly closed to prevent entrance of dust and dirt. Check the wind mechanism and rewind if necessary, but do not use unnecessary force. Test the sprinkler-system attachment to determine its signaling performance. When practicable, make this test in conjunction with operating tests for other equipment of the same system.

Operate the sprinkler-system testing facilities to test the coded sprinkler-system waterflow alarm attachments. After test, restore the attachments to normal, and rewind the attachment mechanisms. The sprinkler-system waterflow attachment should operate for the complete number of alarm signal rounds for which it is designed. The signaling contacts should cause the assigned coded signal impulses to be recorded on the connected control unit circuit, both in the normal operating condition and in the emergency signaling condition. The coded signal mechanism should operate reliably and uniformly, with no sticking, binding, or other irregularity. The sprinkler-system waterflow attachment should be in the normal standby condition after the alarm signal has been completed and the sprinkler-system testing facilities have been restored to normal.

Operate the sprinkler-system testing facilities to test the noncoded sprinkler-system waterflow attachment. The sprinkler-system attachment should operate reliably so that its signaling contacts will operate the connected automatic transmitter or control unit. The attachment should be in the normal standby condition after the sprinkler-system testing facilities have been restored to normal.

Fire-Phones. The inspection of fire phones consists of checking the weather box, instrument, target light, and connecting wiring or conduit for physical damage. Make sure that the marker light is not burned out. The weather box and target marking should be brightly painted.

Testing of the fire phone involves nothing more than lifting the receiver and announcing the phone identification number to the central fire alarm communication operator.

Exercise (421):

1. Match each of the statements listed in column B with the system/subsystem in column A with which it is most closely associated with. Each statement may be used once, more than once, or not at all.

Column A

____ 1. Noncoded fire alarm box.
____ 2. Coded fire alarm box.
____ 3. Noncoded sprinkler-system waterflow alarm.
____ 4. Coded sprinkler-system waterflow alarm.
____ 5. Fire phones.

Column B

a. Testing of this unit involves nothing more than lifting the receiver and announcing the identification number.
b. Testing of this unit involves moving the pull-lever for maximum travel and releasing it.
c. These units should operate for the complete number of alarm-signal rounds for which they are designed.
d. The moving parts within these units must be replaced after each use and/or test.

e. This attachment should operate reliably so that its signaling contacts will operate the connected automatic transmitter or control unit.

f. When inspecting this unit, you should check the target light to be sure it is operational.

g. To test this unit, you must unlock the cover so that it may be moved away from the contact-actuating plunger.

422. Indicate whether given statements concerning the testing and inspection of wet-pipe sprinkler systems are correct. If a statement is invalid, correct it.

Testing of the System. Be sure to notify the central fire alarm communications center and building occupants before system tests are made and after they are completed. To test the alarm check valve, you should first take readings of the pressure gages below and above the alarm clapper valve. These readings should be approximately the same. The pressure gage above the clapper valve may show a higher reading than does the lower gage, because of a higher static pressure at night or pump pressure surges trapped above the alarm check valve. This indicates that the valve clapper is properly and firmly seated. The lower gage pressure reading would indicate if the proper water pressure is present in the supply riser.

Make certain that there is no leakage from the retarding chamber. Continuous leakage through the retarding chamber indicates that the alarm valve clapper is not seated properly, and that it may have to be cleaned or that the rubber facing on it may have to be replaced.

Test the alarm valve by opening the inspector's test valve at the top of the sprinkler system. This action is equivalent to the opening of a single sprinkler head. The water pressure in the system above the alarm check valve will now drop, causing the clapper valve to open. Water enters the retarding chamber, and this permits a building-up of water pressure under the circuit closer—which actuates the electric alarm and simultaneously results in a flow of water to the water motor alarm gong. If neither alarm operates properly with a good flow of water from the inspector's test valve, check to see if the alarm shutoff valve between the alarm valve and retarding chamber is open. This valve should be sealed in the OPEN position. If this valve is open, inspect the alarm devices and pipe connections from the alarm valve. In case of failure of the electric alarm, the cover of the circuit closer should be removed. The test should be repeated and the movement of the diaphragm or mercury switch observed. If they have actuated properly, the trouble will be in either the electric circuit or electric bell, both of which should be checked. Failure of the water motor alarm gong is usually the result of a plugged screen, which can be cleaned by removing the strainer of the water motor alarm. Do not test the water motor alarm gong during periods of prolonged cold weather. Electric alarms may be tested during freezing weather by removing the cover of the circuit closer and making contact by hand.

An alternate method of testing the alarm equipment is to use the test bypass valve. Opening this valve permits water to flow to the retarding chamber directly from the supply riser without destroying the excess system pressure trapped by the clapper in the alarm valve.

Testing of waterflow indicators are made by opening the inspector's test valve at the top of the sprinkler system until an alarm is received. The vane of the indicator which extends into the pipe is deflected, closing electric contacts mounted in the top of the indicator to produce an electric alarm. If the alarm is not produced, the trouble may be in the electrical parts of the waterflow indicator. Open the cover and check the electric circuit, contacts, and their adjustment.

If false alarms are received, they may be the result of pressure surges or "water hammer." Frequently false alarms may be reduced by relieving trapped air pressure from the top of the system. To prevent false alarms, it may be necessary to increase the time delay of the electric retard device (normally set for 20 to 30 seconds), but don't increase it to more than 60 seconds. If false alarms continue, further adjustment should be made by the manufacturer. False alarms from alarm check valves may occur because of improper operation of the retarding chamber, an obstructed bypass check valve (internal or external), or faulty adjustment of the pilot valve used on some types of alarm check valves. In most cases, the trouble may be remedied by careful cleaning and overhauling. If false alarms continue, it is advisable to refer them to the manufacturer. In rare cases it may be necessary to maintain an abnormally high excess pressure above the alarm check valve by adding water through the pumper connections to the sprinkler system. However, it must be emphasized that this is only a *temporary* measure and does not correct the malfunction.

You conduct drain flow tests by using the main drain valve to determine if there are partially closed valves or obstructions in the water supply system. Before opening the main drain valve, make sure that water to be drawn off will be disposed of without causing damage. Make the drain flow test at all risers by opening the 2-inch drain valve to FULL OPEN position until the system or lower water pressure gage shows a steady reading. This pressure is called "residual" pressure and indicates the water pressure available in the sprinkler system with the 2-inch drain valve fully open. The normal "static" pressure is indicated by the water gage when the 2-inch drain valve is closed. The difference between static and residual pressure at a selected riser at a point which is remote from the source of water supply should be permanently recorded for comparison with future drain tests. Make recorded drain flow tests from the same riser at each testing. Where systems are divided into two or more branches, recorded tests should be made from a selected riser in each branch. The drop in pressure should not differ materially from previously established readings. When this drop differs more than 10 to 20 percent of its normal value, an obstruction (such as a partially closed valve in the water supply system) may be indicated. An immediate investigation should be made and proper remedial action taken. Excessive demand on the base water supply during the drain tests may account for a difference in the static and residual readings from those previously established.

Inspection of the System. To have a dependable sprinkler system, you must be sure that it is in good working condition. This is done by making frequent inspections. When inspecting wet-pipe sprinkler systems, you are concerned with three major areas: piping, heads, and valves.

Piping. Inspect all sprinkler piping and hangers to determine that they are in good condition. The piping should not be used as a support for ladders, stock or other material. Replace all bent or damaged pipes and missing hangers. Refasten all loose hangers, as they may put an unnecessary strain on the piping and fittings, cause breaks, and interfere with proper drainage.

Check the piping for proper drainage. Piping in wet-pipe systems must be protected against freezing. Freezing can stop the flow of water to sprinklers or cause failure of control and alarm devices. Also, equipment may be seriously damaged or piping may be ruptured, the result being severe water damage or expensive repairs and interruption of protection.

Heads. It is important that you make an immediate examination of sprinklers in areas when changes occur in occupancy, fire hazards, or in heating, lighting, or mechanical equipment. These changes may require different types of sprinkler heads to be installed.

Inspect all sprinkler heads to make sure they are in good condition, clean, not damaged, and free from corrosion. Guards for protection against mechanical injury should be installed if needed. Sprinkler heads in buildings subject to high temperatures such as mess halls, laundries, or other special installations using high operating temperatures should be carefully examined, and any head showing evidence of weakness should be replaced with a head of the proper temperature rating.

Sprinkler heads exposed to corrosive atmospheres should have a special protective coating of wax or lead. Heads that are badly corroded or heavily loaded with foreign material should be replaced. Representative samples of corroded sprinkler heads, the operating condition of which appears doubtful, should be removed and forwarded to testing laboratories for examination and testing.

Partitions or stock should not obstruct the distribution of water discharge from sprinklers. A clearance of at least 18 inches should be maintained under sprinklers. An adequate supply of extra sprinklers should be kept in a cabinet along with a sprinkler wrench. The extra supply should include sprinkler heads of the various designs and temperature ratings similar to those in service so that prompt replacement of fused or damaged heads can be made and full protection restored. Sprinklers for hallways, shafts, and special rooms may have special deflectors.

Valves. Inspect to assure that all valves controlling water supplies to the sprinkler system and within the system (sectional valves) are kept open at all times.

Listed below are inspections common to all control valves. Examine each control valve for the following conditions:

- Valve is fully open and sealed properly in approved manner.
- Operating wheel is in good condition.
- Valve is accessible at all times. If a permanent ladder is provided, check the ladder to see that it is in good condition.
- Valve and its parts are not subjected to mechanical damage. Provide adequate guards if necessary.
- Wrench, when required, is in place.

In addition, inspect the post indicator valves (P.I.V.) to see that the target indicates that the valve is fully open. Try the wrench to feel the spring of the rod when the valve is fully open. Keep the valve about one-quarter turn back from the FULL OPEN position. See that the target glass is in place and clean. Oil the target mechanism periodically. Assure that the P.I.V. head bolts are tight and that the barrel casing is intact.

Inspect the outside screw and yoke valves (O.S. & Y.) to assure that the operating wheel is kept approximately one-quarter turn back from FULL OPEN position and that the valve stem is clean. Tighten or repack the packing glands if water leaks appear at the valve.

Exercises (422):

If one of the following statements is correct, mark it True; if it is False, correct it.

____1. The first thing you should do when testing a wet-pipe sprinkler system is to alert all concerned personnel of the test being conducted and turn off the main water control valve.

____2. To test the alarm check valve, you should first take readings of the pressure gages above and below the alarm clapper valve; they should be approximately the same.

____3. If the valve clapper is firmly and properly seated, the lower pressure gage may indicate a higher reading due to the entrapment of high static pressure surges.

____4. To determine if the proper water pressure is present in the supply riser, you should take a reading from the lower pressure gage.

____5. If, during your inspection, you detect continuous leakage through the retarding chamber, it would be an indication that the alarm clapper is not properly set.

____6. To test the alarm valve, you should open one of the sprinkler heads at the top of the sprinkler system.

____7. If, with a good flow of water, neither alarm operates properly, you should check the alarm shutoff valve between the alarm valve and the retarding chamber to be sure it is not open.

____8. In case of failure of the electric alarm, you should check the strainer of the water motor if the diaphragm or mercury switch has operated properly.

____9. If you wish to test the alarm equipment of a system so equipped, you may elect to use the test bypass valve and thus maintain any excess system pressure trapped by the clapper in the alarm valve.

____10. You may test the waterflow indicators in the system by opening the inspector's test valve and leaving it open until an alarm is received.

____11. If you relieve trapped air pressure from the top of a wet-pipe system, you may eliminate frequent false alarms from the system.

____12. Adding water through the pumper connection to maintain excess pressure above the alarm check valve is a temporary measure that corrects the malfunction.

____13. You can determine if there are partially closed valves or obstructions in the water supply system by conducting drain flow test using the main drain valve.

____14. You should make a permanent record of the difference between static and residual pressure at a selected riser at a point which is near the source of supply for comparison with future drain test.

____15. When inspecting a wet-pipe sprinkler system, you will be concerned with three major areas. These areas are the heads, valves, and water supply.

____16. If a pipe hanger is not secure and not refastened, it may cause breaks, interfere with the drainage of the system, and/or put an unnecessary strain on the pipe and fittings.

____17. When an area protected by a wet-pipe sprinkler system undergoes an occupancy change, the sprinkler system must be examined to determine if the current in-use heads will meet the requirements of the new occupancy.

____18. While inspecting a sprinkler system, you should insure that there is at least 24 to 30 inches of clearance maintained under the sprinkler.

____19. If, while inspecting a sprinkler system, you discover that there is a good chance that mechanical damage could occur to any of the valves in the system, you should take necessary action to have adequate guards provided for the valves.

____20. Both the P.I.V. and O.S. & Y. valves for the wet-pipe sprinkler system should be kept in the FULL OPEN position when the system is in service.

423. Given a series of incomplete statements concerning the testing and inspection of dry-pipe sprinkler systems, complete the statements by filling in the correct word(s) and/or phrase(s).

Testing the System. Be sure to notify the central fire alarm communication center and building occupants both before performing tests and after completing them.

To test the alarm equipment, open the alarm bypass test valve. This will activate the alarm pressure switch and water motor alarm. Shut the valve when the test is completed.

Perform the drain flow test, which determines if water supply lines are blocked or restricted, in the same manner as that used with the wet-pipe system.

All dry-pipe valves should be tested, cleaned, and reset periodically. Test dry-pipe valves by using a throttled main water control valve in order to prevent any large amount of water from entering the sprinkler system. This may be done in the following manner: Close the main water control valve and open the main drain valve. Now open the main water control valve until approximately 5 pounds of pressure shows on the water pressure gage, and then close the drain valve.

The air should be allowed to escape through the inspector's test valve at the top of the system—or in case this connection is not provided, through the priming water level test valve or a low-point drain. When the dry-pipe valve trips, the control valve should be completely closed before a large amount of water has entered the system, and the drain valve should then be opened. The dry-pipe valve should be thoroughly cleaned, examined, and reset. At this time replace rubber gaskets, adjust gages, reface metal seats, and clean and adjust the alarm and quick-opening devices. When an automatic air compressor is provided, it is advisable to check the restriction orifice in the air connection. After the main water control valve is opened and sealed, make a full drain test. Always keep a record of the time necessary to trip the dry-pipe valve and quick-opening device. Failure of a dry-pipe valve to trip should be carefully and completely investigated.

The quick-opening device should function properly during the operational test of the dry-pipe valve. In case the quick-opening device does not operate properly, and cannot be repaired promptly, the dry-pipe valve should be reset and placed in service with the quick-opening device disconnected.

Inspection of the System. Dry-pipe sprinkler system inspections are much the same as wet-pipe inspections in regard to piping, sprinkler heads, and valves. In addition, a record of the air and water pressures and temperature in dry-pipe valve areas should be maintained. These readings should correspond with readings recorded previously. Air pressure should be restored when necessary. If loss of air pressure is excessive, requiring frequent air pumping, the dry-pipe valve, fittings and piping system should be gone over and tightened. During freezing weather, it may be necessary to check pressures and dry-pipe valve area temperatures at frequent intervals.

Make sure that the main water control valve and valves in the connections to alarm devices from the intermediate chamber are in the open position and are sealed.

Check to be sure that the automatic drip valve from the intermediate chamber is free to move by lifting up the push rod which extends through the drip valve opening; if the valve is not equipped with a push rod, insert a pencil through the valve opening. Where the velocity-type automatic drip valve is used, make sure the clapper or ball is off its seat by using the push rod, when this is provided, or by feeling with your finger through the discharge end of the valve.

Before and during cold weather, open the drain valves on all low points to see that the pipes are entirely free of water or ice.

Open the priming test valve to ascertain the level of priming water, if required, and keep it open until air begins to escape. This is done to make sure that the dry-pipe valve is not water-columned and that there is no water in the pipes where it can freeze.

If a quick-opening device is attached to the dry-pipe valve, a sudden drop in air pressure may cause the quick-opening device to trip the dry-pipe valve. Open the priming test valve only slightly and close it immediately after air begins to escape. If the air pressure in the system is above the prescribed limit, shut off the quick-opening device to prevent tripping of the dry-pipe valve and open the priming test valve until the system air pressure is reduced to the prescribed limit. Now close the priming test valve. Before opening the quick-opening device control valve, reduce the air pressure in the quick-opening device until it matches the pressure in the system. In cases where there is no provision made for bleeding air from the quick-opening device, the air pressure may be reduced by loosening the air gage.

After making tests for priming water level, take care that no air leakage occurs at the test valves after they have been closed. Leaks at test valves may be detected by wetting your fingers and placing them over the outlet end of the valve, or by wetting the valve stem close to the packing nut. Leaks can be stopped by tightening the stuffing box or plugging the outlet end. Dry-pipe valves occasionally trip prematurely from a slow leakage of air through the air connection from the air compressor. The valve controlling the air supply from the manually operated compressors must be kept tightly closed. Also, dry-pipe valves occasionally trip prematurely during water surges; this may be corrected by adjustment of the operating screw.

Exercises (423):

Fill in the blanks in the following statements.

1. To test the alarm equipment of a dry-pipe sprinkler system, you should open the ______ ______ ______ ______.
2. The dry-pipe valves are tested by using a ______ ______ ______ ______ valve in order to prevent any large amounts of water from entering the sprinkler system.
3. When testing the dry-pipe valve, you should ______ the main water control valve and then ______ the main drain valve.
4. If an inspector's test valve is not provided for in a dry-pipe sprinkler system, then the air may be allowed to escape through the ______ ______ ______ ______ ______ or a ______-______ ______.
5. During your test, the control valve should be closed and the drain valve opened when the ______-______ ______ trips.
6. It is advisable to check the ______ ______ in the air connection when an automatic air compressor is provided.
7. The dry-pipe valve should be reset and placed in service with the ______-______ ______ disconnected when it (the device) does not function properly and cannot be repaired promptly.
8. During your inspection of a dry-pipe sprinkler system, you should make a record of the ______ ______ ______ ______ and the ______ in the dry-pipe valve area.
9. Frequent air pumping is required if the ______ ______ ______ ______ is excessive, and the dry-pipe valve, fittings, and piping system should be gone over and tightened.
10. If so equipped, you lift up on the push rod, which extends through the valve opening, to check the ______ ______ ______ from the ______ ______ to be sure it is free to move.
11. You can use your finger to feel through the discharge end of the valve, where the velocity-type automatic drip valve is used, to make sure that the clapper or ball is ______ ______ ______.
12. If required, you can open the ______ ______ to ascertain the level of the priming water.
13. To make sure that the dry-pipe valve is not water-columned and that there is no water in the pipes where it may freeze, you should open the ______ ______ ______.
14. A sudden drop in air pressure may cause the ______-______ ______ to trip the dry-pipe valve, if such a device is attached.
15. Where there is no provision made for bleeding air from the quick-opening device, the air pressure may be reduced by ______ ______ ______ ______.
16. The occasional premature tripping of valves during water pressure surges may be corrected by adjustment of the ______ ______.

424. Indicate whether given statements concerning the testing and inspection of deluge sprinkler systems, special systems, and standpipe systems are correct. If a statement is invalid, correct it.

Deluge Systems. Be sure to notify the central fire alarm communcations center and building occupants both before alarm tests are made and after they are completed.

Testing the system. To test the alarm equipment, open the indicator alarm valve. This will activate the alarm pressure switch and water motor alarm. Shut the valve when the test is completed.

Perform the drain flow test for the deluge system to determine if water supply lines are blocked or restricted. Do this in the same manner as for the flow test on the wet- or dry-pipe system.

Periodically test all deluge valves. To perform this test, first close the main water control valve so that water will not enter the system piping. Then raise the temperature in the most remote HAD, or the test HAD if one is provided, by using the electric tester (heater). This will test the operation of the HAD system and the tripping mechanism. The electric heater should not be used in areas considered subject to explosive atmospheres. A bucket of hot water or a cloth dipped in hot water may be used instead. Activation of the HAD will cause the system to operate as described in the section on the deluge operation.

Inspection of the system. The deluge system inspections follow the same guidelines as those performed on the wet and dry pipe in regards to piping and valves. In addition, the system and supply water pressure gages should indicate the normal water pressure. Also make sure that the main water control valve and the valves in the connections to alarm devices are in the OPEN position and sealed. Check the drip valve for free movement by lifting up the push rod which extends through the drip valve opening; if the valve is not equipped with a push rod, insert a pencil through the valve opening. Where the velocity-type automatic drip valve is used, make sure the clapper or ball is off its seat by using the push rod (when this is provided) or by feeling with your finger through the discharge end of the valve. Inspect the HADs and connecting tubing for physical damage and corrosion.

Special Systems. Inspect and test to insure that all inclosures designed to confine the gas within the protected space are maintained in good condition, and that all automatic shutters used in connection with inclosures are fully operative. See that all piping and apparatus located at the carbon dioxide storage units are adequately protected against accidental damage and obstruction. Carbon dioxide storage units located outdoors should be protected from wet weather by noncombustible inclosures. Check any changes that may have been made in the hazard, surroundings, and apparatus that affect the protection required.

Check the amount of gas in storage cylinders by weighing them. In the high-pressure systems, replace or recharge any cylinder showing a loss of gas of more than 10 percent by weight of original content. Refill any tank in the low-pressure system showing more than 10 percent loss of contents if its capacity is equal only to the amount of gas required to protect the largest hazard. For systems designed to give immediate protection for the largest hazard after a fire is extinguished, the quantity of gas to be maintained should be equal to twice that required for the largest hazard.

Test automatic and manual release devices for good operating conditions in accordance with the testing procedures outlined for that particular system.

Standpipe Systems. The inspection and testing procedures for standpipe systems are quite simple. The system should be charged with water to the operating valve, which is usually the wheel type. Operating valves should be sealed closed. This valve must be checked periodically for proper operation, gasket condition, presence of corrosion, and leaks.

The hose should be inspected for general condition, dryness, and for proper position on the swing-out rack or holds. It should be removed and reracked periodically so that it will not wear excessively at the bends. The swing-out rack should be checked for ease of operation.

The threads on the combination nozzle and couplings should not be damaged, and the rubber gaskets should be in good condition. The combination nozzle should not be obstructed, and the operating valve should work freely. Standpipes should be flow tested and flushed periodically. Check the operating valve for operating condition at this time.

Safety Precautions. The end of the section is a most opportune time and place to remind you about safety. All the information and training in the world is of little value unless you think about safety and then *practice* it. Here are a few general tips that are applicable to most of your jobs.

Most of the hazards and dangers in maintenance of fire alarm electrical wiring and devices can be eliminated by following a few simple rules.

a. Keep tools in good condition and repair. Replace wornout screwdrivers, pliers, and wrenches.

b. Use ladders that are strongly constructed and in good repair. When working on ladders, be sure they are in position and cannot slip.

c. Whenever possible, before starting to work, shut off the power by pulling the main switches and tagging them. The best way to insure that the circuits are not energized while your work is in progress is to remove the circuit fuses.

d. Test all wires with a voltmeter or test lamp to determine whether or not they are energized. *Never* use your fingers or tools to test circuits.

e. Only experienced personnel should attempt to work on energized wires. Use tested protective equipment and devices on all hot-wire work. Although insulated tools, such as pliers and screwdrivers, are not *absolute* protection, *always use them* while working on hot wires. Taping handles of pliers or screwdrivers does *not* insulate them. DO NOT work on hot wires when you are wet. When working on hot wires, stand on boards, a dry ladder, or a rubber-insulated blanket to keep from grounding yourself. Remember that the conduits or armored cables are well grounded.

f. Do not smoke or expose open flame devices around batteries. Never test a battery by short-circuiting the terminals. The sparks or flame caused may ignite the explosive gases in the battery and blow battery acids out through the sides and top of the battery, causing acid burns.

Air Force Regulation 92-1 contains detailed information on the inspection and testing requirements and should be adhered to at all times.

Exercises (424):

If one of the following statements is correct, mark it True; if it is False, correct it.

___1. Both the building occupants and the fire alarm communications center should be notified before alarm tests are made and after they are completed.

___2. When you test the alarm equipment on a deluge system, opening the indicator alarm valve will activate the alarm pressure switch and water motor alarm.

___3. To test the deluge valve, you should close the main water control valve and then raise the temperature in the most remote HAD if a test HAD is not provided.

___4. By using the electric tester to raise the temperature of the test HAD, you can test the operation of the HAD system and the tripping mechanism.

___5. Where the velocity-type automatic drip valve is used in a deluge system, you should make sure that the ball or clapper is on its seat by using the push rod (where the rod is provided).

___6. When inspecting and testing special systems, you should insure that all automatic shutters used in connection with inclosures are fully operative and sealed open.

___7. If during your inspection of a carbon dioxide system, you discover one 100-pound storage cylinder with only 93 pounds of gas in it, the cylinder need not be replaced or recharged.

___8. In a system designed to give immediate protection for the largest hazard after a fire is extinguished, the quantity of gas to be maintained should be equal to three times that required for the largest hazard.

___9. You should check a standpipe system to insure that the system is charged with water to the operating valve which is usually of the globe type.

___10. The operating valves in a standpipe system should be sealed open.

___11. The hose on a standpipe system should be removed and reracked monthly so that it will not wear excessively at the bends.

___12. As a safety factor, you should remove circuit fuses while working on a circuit to insure that the circuit is not energized.

___13. Sparks or flame may cause the gas in a battery to explode, blowing battery acid out through the sides and top of the battery, causing acid burns.

2-5. Heat and Smoke Ventilation

Heat and smoke behavior in type "N" or type "C" facilities vary greatly with materials and assemblies used in the construction and the fire loading factor. In general, heated products of combustion are lighter than the surrounding air and, therefore, rise until obstructed by ceilings or roofs. Upon reaching the ceiling they spread out and form a layer which is supported by the cooler air beneath. Without vents, this layer of hot gases becomes progressively deeper until the facility is completely filled. Smoke and hot gases confined in buildings during fires interfere with access and visibility for firefighting and rescue and serve to maintain high temperatures and spread fire. If allowed to accumulate in a building, hot unburned products of combustion will ignite explosively when a supply of oxygen is suddenly made available. The selection of recognized heat and smoke venting devices immeasurably contribute to ridding facilities of these conditions and aids in locating the seat of the fire and in complete extinguishment.

425. Complete statements concerning heat and smoke venting devices and principles.

Heat and smoke venting devices are not normally associated with facility installed services such as air conditioning systems, exhaust systems, etc., which, in most cases, contribute to the spread of fire unless they are turned off. Installed services may be useful for such things as ridding the building of smoke *after* extinguishment. Fire vents are most applicable in one-story buildings of large areas which lack adequate subdivisions. They are also very effective for use in windowless or underground buildings. Adequate venting is of special importance in high hazard, storage, industrial, and processing facilities where the presence of flammable vapors or combustible dust may result in rapid fire spread. Keep in mind that vents should not be used in place of automatic sprinkler systems.

Some factors which relate to effective venting are as follows:

- The quantity of heat to be vented depends on the quantity of combustibles which are burning and the rate of burning.
- Venting capacity is proportional to total vent area.
- Draft curtains (curtain boards) increase vent effectiveness because they increase stack height of smoke and confine heated gases.
- Several small vents rather than one vent of equal area are more effective since gas temperatures decrease rapidly as they travel away from the fire.
- Roof height, within normal ranges of height, will not affect vent effectiveness.

Venting Methods. To accomplish the venting effectively, any one of several individual methods or a combination of methods may be used.

Exterior wall windows. Exterior wall windows are a common method of providing some venting under favorable conditions, that is, if the windows are located close to the roof and the panes are constructed of ordinary glass. As the heat from the fire builds up, the glass will become weakened and eventually fail from prolonged exposure to heat. Although some venting is provided with ordinary window glass, such means are not as effective as are specially designed venting devices. Ordinary windowpanes in sawtooth roofs are a variation on this method of venting.

Continuous gravity vents. This type of vent consists of continuous narrow slot openings below a weather hood. It continuously operates to remove stale air from the facility and, consequently, it also operates and removes the products of combustion and heat resulting from a fire. If such vents are equipped with shutters, it is desirable to equip the shutters with fusible links so they will open during a fire and increase the effective vent area.

Unit-type vents. These vents are relatively small, usually of 16 to 100 square feet in area, composed of a metal frame and metal housing with a hinged damper which can be operated manually or automatically by the use of fusible links. These vents are specifically designed to vent off the products of combustion which result from a fire. Where these vents are used, it is desirable to couple them to other protective devices such as sprinkler systems, fire doors, or other devices so that all protective systems will operate simultaneously.

Monitors. Roof monitors with louvers or thin glass (not over 1/8-inch thick) windows in the sides may provide the needed venting if they are properly spaced and subdivided.

Vent Size and Spacing. The size and spacing of vents is dependent upon the heat release characteristics of the building contents. The following occupancy groupings have been suggested by the National Fire Protection Association Committee on Building Construction.

Low-heat release occupancy. This includes those buildings or portions of buildings containing scattered small quantities of combustibles. Maximum spacing between these vents will be 150 feet between centers.

Moderate-heat release. This occupancy includes those buildings or portions containing moderate quantities of combustible materials which are fairly uniformly distributed and will be spaced a maximum of 120 feet between centers.

High-heat release. This occupancy includes buildings, or portions, containing either hazardous operations or concentrated quantities of combustible materials or both. Spacing will be 75 to 100 feet between centers.

These recommendations are based on ratios of effective area of vent openings to floor areas for the following occupancy classifications.

1. Low-heat release contents — 1:150.
2. Moderate-heat release contents — 1:100.
3. High-heat release contents — 1:30 to 1:50.

Venting Aids. In large facilities not subdivided by walls or partitions, curtain boards should be installed to delay and prevent the horizontal spread of heat needed to obtain the "stacking" action required to operate venting devices. Curtain boards are constructed of sheet metal or other noncombustible material. The distance between curtain boards in low or moderate heat occupancies does not normally exceed 250 feet and the curtained areas are limited to a maximum of 50,000 square feet. In high-heat release occupancies, the distance between curtain boards does not exceed a maximum of 100 feet and the curtained areas are limited to 10,000 square feet.

In areas where moderate ceiling heights are encountered, the curtain boards should be a minimum of 6 feet in height. In special hazard areas, the curtain boards may have to be doubled in length or be extended to within 8 to 10 feet of the floor when very high roofs are used.

Exercises (425):

Complete the following statements by filling in the correct word(s), number(s), and/or phrase(s).

1. Fire vents are most applicable in one-story buildings of large areas which lack ______ ______.
2. Adequate venting is of special importance in facilities where the presence of ______ ______ or ______ ______ may result in rapid fire spread.
3. When considering vents, you must keep in mind that they should not be used in place of ______ ______ ______.
4. Vent effectiveness is increased by the use of ______ ______ because they increase stack height of smoke and confine heated gas.
5. A common method of providing some venting, under favorable conditions, is the use of ______ ______ ______; however, these must be located close to the roof and the panes constructed of ordinary glass.
6. A continuous gravity vent consists of a continuous ______ ______ opening below a weather hood.
7. If continuous gravity vents are equipped with shutters, they (the shutters) should have ______ ______ so they will ______ during a fire and increase the effective vent area.
8. Unit-type vents are specifically designed to vent off ______ ______ ______ ______.
9. If properly spaced and subdivided, ______ ______ with ______ or thin glass windows in the sides may provide the needed venting.
10. The size and spacing of vents is dependent upon the ______ ______ ______ of the building contents.
11. In buildings containing small quantities of combustibles, vents should be so located that the maximum between center spacing of the vents will not exceed ______ ______.
12. In an area of high-heat release, the vent area for 150,000 square feet of floor space should be from ______ to ______ square feet.
13. In an area of moderate-heat occupancy covering 200,000 square feet of floor space, there should be a minimum of ______ curtained areas each containing a maximum of ______ square feet, and the distance between the curtain boards should not exceed ______ feet.
14. When an area under a very high roof is to be curtained off, the curtain boards may be extended to within ______ to ______ feet of the floor.

2-6. Fire Extinguisher Criteria

Portable fire extinguishers were discussed in Volume 2 to acquaint you with their physical makeup, operation, and maintenance procedures—and to give you a bit about inspecting them. In this section you will gain information concerning the rating of extinguishers and where they should be located. For example, the following information will answer such questions as these: How large a fire is the 2½-gallon water extinguisher designed to extinguish? Where should an extinguisher be placed in a building or designated area? These questions and many more like them will be answered in this section.

The base population expects you, as a firefighter, to be an expert in all phases of fire protection. Because of this trust, people frequently ask firefighters for recommendations as to which fire extinguishers are safe, reliable, and the proper type for a given hazard. So that you may answer these questions intelligently, let us start with information that will help you to select the correct extinguisher to be placed in a given building or designated area.

426. Point out factors in the rating and classification of portable fire extinguishers.

Rating and Classifying Portable Fire Extinguishers. Physical tests are conducted by Underwriters' Laboratories to determine the potential fire extinguishing capabilities of fire extinguishers. The rating is given as a number and the classification as a letter. These ratings and classifications appear on the label of each fire extinguisher to indicate its expected capability.

Rating and classification for use on Class A fire. Usually the rating and classification will appear something like 4-A, the letter "A" indicates that it is to be used on Class A fires only. The number "4" indicates that this particular extinguisher is expected to extinguish approximately twice as much fire as an extinguisher with a 2-A rating and classification, or four times as much as one with a 1-A rating and classification. (A detailed explanation of how the number rating is arrived at is contained in the *Fire Protection Handbook.*)

Rating and classification for use on Class B fires. The rating and classification appearing on this type of extinguisher may be, for example, 10-B. The letter "B" indicates that the extinguisher may be used on Class B fires only. The number "10" indicates that the extinguisher is expected to extinguish 10 square feet of deep-layer flammable liquid fire or 10 times as much Class B fire as an extinguisher rated and classed 1-B.

Classification for use on Class C fires. Since Class C fires usually are a combination of Class A and B materials, no number will appear in the classification. The classification will appear on the label as simple "C," which means that it may be used on energized electrical equipment. The size of the extinguisher will be selected to assure adequate protection for the amount of Class A and B materials used in the construction of the electrical equipment.

Classification for use on Class D fires. No number is used in the classification for this type extinguisher. The main reason is that there are so many metals that each extinguisher would require extremely different ratings. Usually, the effectiveness of this type of extinguisher is marked on the label of each extinguisher. Always check the label before the extinguisher may have to be used. It's too late to read a label after fire starts.

Multiple ratings and classifications. So that you will not become confused about multiple rating and classifications, such as a fire extinguisher rated 2-A, 12-B, C; we will see how such rating and classifications are made. Using the example given above, you can quickly see that this particular extinguisher may be used on Class A, B, and C fires. You can expect it to extinguish twice as much Class A fire as another extinguisher rated and classed as 1-A. When used by an experienced operator, it could extinguish 12 square feet of flammable liquid fire or 12 times as much Class B fire as one rated and classed 1-B. Also, the extinguisher may be used on electrical equipment. Remember, the size of the extinguisher must be adequate to extinguish any Class A or B materials used in the construction of the electrical equipment.

Exercises (426):

1. What do the ratings and classifications that appear on the label of each fire extinguisher indicate?

2. An extinguisher with 6-A on the label is expected to extinguish how much fire when compared with an extinguisher which is rated as 2-A?

3. The number (rating) that appears on the label of an extinguisher to be used on Class B fires, only, has what significance?

4. How do you determine what size extinguisher to select when an extinguisher is to be used for Class C fires?

5. Since extinguishers for use on Class D fires do not carry a specific rating, but only a classification, how can you tell how effective a particular extinguisher is supposed to be?

6. When choosing an extinguisher with multiple ratings and classifications, how will you know the effectiveness of the extinguisher on a given class of fire?

7. With the exception of one class of fire, extinguishers which carry multiple ratings and classifications may be used on any and/or all classes of fire (depending upon the particular type extinguisher) except for what class of fire?

427. Given a list of statements concerned with selecting and locating portable fire extinguishers, complete the statements by filling in the correct word(s), phrase(s), and/or number(s).

Selecting Extinguishers. It goes almost without saying that a lot of excitement and confusion accompanies each fire alarm or fire. The decision of which extinguisher to select at this time must be correct. Planning ahead and placing the extinguisher close to the hazard will help in selecting the correct one. Placing extinguishers that are multipurpose in use and marking the location so that they can be easily and quickly reached will also help in selecting the correct one. The most important thing the planner can do in the area of fire training is to train his personnel to identify and use the correct extinguisher. He must also keep up a continuous proficiency training program.

Several items must be considered in order to determine the number of extinguishers to be placed within a building or designated area. Those that must be considered are the area and arrangement of the building, the severity of the fire hazard, the anticipated classes of fire, the distance of travel for each extinguisher, the anticipated rate of fire spread, the intensity and rate of heat development, and, finally, the anticipated density of smoke which could be generated.

Building protection and occupancy hazards are considered separately for extinguisher distribution. For instance, building protection will be provided by suitable Class A extinguishers, and occupancy protection provided by Class A, B, C, or D extinguishers suitable for the existing hazards. An example of this would be to supply water extinguishers for a wooden frame building. If the building contained complex electrical equipment, then CO_2 or dry-chemical extinguishers could be supplied for the equipment protection. Each room within a building should be evaluated separately to determine its grading as a light, an ordinary, or an extra-hazard area. An explanation follows to assist you in this grading.

Light Hazard. Here the amount of combustible materials or flammable liquids present is such that only small fires may be expected. This would include offices, schoolrooms, churches, assembly halls, telephone exchanges, etc.

Ordinary hazard. Here the amount of combustible materials or flammable liquids present is such that fires of moderate size may be expected. These would include mercantile storage and display, auto showrooms, parking garages, light manufacturing, school shop areas, and warehouses not classed as extra hazard.

Extra hazard. Here the amount of combustible materials or flammable liquids present is such that fires of severe magnitude may be expected. These would include woodworking, auto repair, and aircraft servicing shops; warehouses with combustibles stacked 12 to 14 feet, or higher; and buildings containing processes such as flammable liquid handling, painting, and dipping.

Distribution of Extinguishers. Once you have determined what kind of extinguishers are to be placed in a given area, you must determine how many extinguishers will be needed and where they should be located.

Number. Table 2-1 gives you a guideline to use in the distribution of extinguishers. Note that the information includes the minimum rating, maximum travel distance (distance actually walked to the extinguisher), and area classification.

To figure the number of extinguishers, you must know how many square feet of area is to be protected and what is the type hazard involved. If you have an office building (light hazard) with 6,000 square feet of floor space, an extinguisher rated 2A (a 1½-gallon stored pressure water extinguisher for example) should meet the requirements. Now check and see if the extinguisher can be located so that it may be reached from any point by walking 75 feet or less. If it can, you are OK; if not, then additional extinguishers must be provided to meet the 75-foot travel requirement.

The portion of Table 2-1 pertaining to "B"-rated extinguishers needs some explanation. The ratings given are for extinguishers rated before the first of June 1969; ratings for

TABLE 2-1

DISTRIBUTION OF PORTABLE FIRE EXTINGUISHERS

Minimum Rating for Area Specified	Maximum Travel To Extinguishers	Areas to be Protected Per Extinguisher		
		Light Hazard Occupancy	Ordinary Hazard Occupancy	Extra Hazard Occupancy
1A	75 Ft	3,000 Sq Ft	*	*
2A	75 Ft	6,000 Sq Ft	3,000 Sq Ft	*
3A	75 Ft	9,000 Sq Ft	4,500 Sq Ft	3,000 Sq Ft
4A	75 Ft	11,250 Sq Ft	6,000 Sq Ft	4,000 Sq Ft
6A	75 Ft	11,250 Sq Ft	9,000 Sq Ft	6,000 Sq Ft
4B	50 Ft	+		
8B	50 Ft		+	
12B	50 Ft			+

NOTE: + = Placement for class B extinguishers.
* = Special approval required for less than indicated.

these extinguishers have since changed. To determine the new ratings use the following:

RATING		TRAVEL DISTANCE	
Old	*New*	*Old*	*New*
4B	5B	50 ft.	30 ft.
	10B		50 ft.
8B	10B	50 ft.	30 ft.
	20B		50 ft.
12B	20B	50 ft.	30 ft.
	40B		50 ft.

If an extinguisher of the smaller rating is chosen, it must be located close to the area to be protected, thus the dual-distance requirements for "B" extinguishers.

Location and mounting. As we said, before, there are maximum travel distances involved for the various types of extinguishers. Class "C" extinguishers should be located as close to the hazard as possible. Class "D" extinguishers must be within 75 feet of the hazard.

After determining the number of extinguishers required and where they are to be located, you must mount the extinguishers. The following will give you some guidance in the mounting of your extinguishers.

- Extinguishers exceeding 40 pounds gross weight will be mounted with the top of the extinguisher not more than 3½ feet from the floor.
- Extinguishers of 40 pounds or less will not be mounted so that the top is over 5 feet above the floor.
- Extinguishers will be mounted so that there is not less than 4 inches of clearance between the bottom of the extinguisher and the floor.
- If the extinguisher is to be mounted in an area where temperatures are outside a range of +40° F to +120° F, they must be provided with a suitable enclosure to maintain normal operating temperatures.
- The extinguisher must be mounted so that it is easily seen, readily accessible, and immediately available.
- The extinguishers should be mounted along normal paths of travel, near exits, and free of obstructions.

Exercises (427):

Fill in the blanks in the following statements.

1. The most important thing you can do, in the area of fire training, when planning extinguisher needs is to train personnel to ______ and ______ the correct extinguisher.
2. The class of extinguisher selected for occupancy protection of a building will be determined by their suitability for the ___ ___.
3. A hazard grading should be made on ___ ___ within a building to determine its extinguisher needs.
4. Areas where the amount of combustible materials or flammable liquids present is such that only small fires may be expected would be graded as ______ ______ areas.
5. A base exchange retail sales store should be graded as an ______ hazard area.
6. For a warehouse to be given an extra-hazard grading, the combustibles within it are stacked ______ to ______ feet or higher.
7. To figure the number of extinguishers needed for a building, you must know two factors; these are (1) ______ and (2) ______.
8. An extinguisher rated as 3A is considered as the minimum required for an area of ordinary hazard occupancy of not more than ______ square feet as long as the extinguisher may be reached by traveling nor more than 75 feet.
9. If an extinguisher was rated as 5B on 1 August 1970, the maximum travel distance to the extinguisher in an area of ordinary hazard occupancy would be ______ ______.
10. The extinguishers for use on Class D fires must be no more than ______ ______ from the hazard.
11. A 15-pound CO2 extinguisher with an empty cylinder weight of 37.5 pounds will be mounted so that its top will not be over ______ ______ from the floor.
12. If you find an extinguisher properly mounted with its top 48 inches above the floor, you should expect the extinguisher to weigh ______ ______ ______ ______.
13. When mounting a 2½-gallon extinguisher 28 inches tall on a wall, the top of the extinguisher would be ______ ______ from the floor if it were mounted as low as permitted.

CHAPTER 3

Water Supply and Requirements

THE PURPOSE of a water supply system is to supply the water needed for domestic, industrial, and fire protection. Domestic demands include water for drinking, cooking, washing, swimming pools, sewage disposal, laundering, and watering of cultivated areas. Industrial demands include such base requirements as central and local heating and cooling equipment, engineering shops, liquid fuel dispensing systems, and paint spray booths. Fire protection demands include water for hose-line operations and for installed devices such as sprinklers, standpipes, and deluge systems. As a fire protection specialist, you must ascertain that the base water supply is adequate for fire protection needs. In order to accomplish this, you must have an understanding of those portions of the base water supply system that have a direct bearing on the needs for fire protection.

428. Indicate whether given statements concerning the requirements for supplies and water supply test are correct. If a statement is invalid, correct it.

The most important factors that govern a water supply system are the reliability and capacity of the source, the distribution system, and the storage facilities. A full knowledge of any existing deficiencies will better enable you to cope with the available supply in the most effective manner possible, even though its improvement may be beyond your ability or authority. As a fire protection specialist, you will be expected, when called upon, to give an intelligent appraisal of the water supply system at your installation. Such questions as the following may be asked: How much water must be stored? What type of water storage is best suited for the installation? What provisions should be made for emergency supply and distribution of water? Of what type and size should the normal distribution system be? What are the different spacing requirements for fire hydrants? How much water is available for firefighting purposes at any given point on the installation? As a fire protection specialist, you will be expected to answer these questions as well as many others that may arise.

Daily Needs. If at all practical, the primary water supply for an Air Force base should be acquired from a nearby municipality or private water company. However, if this is not practical, the water supply may come from wells, canals, streams, rivers, lakes, or ponds, depending on the location of the base. The primary supply should include a pressure source in the system; and to insure emergency reliability in the event of failure of one system, it should originate from two independent sources. When the supply is dependent upon ground water, careful attention should be given to the fluctuation of the ground water table from season to season and from year to year. When the supply is acquired from nearby municipalities, you must be sure that the system is ample and dependable. When the water source is from wells, not less than two should be provided. At least twice as much water per day should be available as is consumed during an average day. It is advisable, under these conditions, to have standby pumping units which have power sources separate from the main system. This provision will give protection when the normal power source is out of order because of fire or other unforeseen causes.

The capacity of the water system must be sufficient to meet the requirements of industrial and domestic facilities, irrigation and sanitary needs, drinking water, and emergency fire demands. The big difference between static pressure and flowing pressure should be fully realized at all times. The only true test of pressure is the ability of the outlet to deliver a given number of gallons over a certain period of time at a sufficient pressure for firefighting purposes. Consequently, static pressures are unimportant, as are the pressure readings when peak domestic requirements are not being fulfilled. You should test the pressure for firefighting water flow while the other users of water are at peak demand. If the pressure and flow meets the demand, you know you have enough water for firefighting requirements during other times of lower demand. Special equipment is required to make this test, such as the Bourdon gage and the pitot gage.

Fire Flow Test. The flow test is based on measurement of pressures at several hydrants. If mains are small, flow from two hydrants gives the required results. Large mains may require as many as five hydrants. Three hydrants are enough at most installations. One of the three hydrants, called the residual hydrant, is the farthest from the large supply mains. A cap for one of the $2\frac{1}{2}$ inch outlets of the residual hydrant is replaced with a similar cap fitted with a pressure gage (bourdon gage). The hydrant is opened and the pressure recorded. Since the hydrant is capped no flow occurs. A $2\frac{1}{2}$ inch outlet cap of each of the other hydrants, called flowing hydrants, used in the test is replaced with a similar cap fitted with a pressure gage. The other $2\frac{1}{2}$ inch outlet cap of these hydrants is removed and the outlet diameters are measured to the nearest one-sixteenth of an inch. The valves of all hydrants in the test group are then opened in succession and the pressure is read at all hydrants simultaneously. The pressure read at the flowing hydrants is the velocity pressure, or the pressure caused by the velocity of the discharging water. The pressure at the residual hydrant is the pressure remaining in the system. With the use of the pitot tubes, and velocity pressure gages, the velocity pressure can be measured slightly more accurately. The pitot tube is held in the center of the stream 1 inch from the face of the outlet. The drop in pressure at the residual hydrant depends upon the number of flowing hydrants and the extent to which each is opened. The openings of the flowing hydrants are adjusted so that the pressure at each of these hydrants is not greater than 10 psi, and the drop in pressure at the residual hydrant is at least 10 psi. These pressures are used to compute hydrant discharges.

Velocity pressure. Using velocity pressure, the discharge of each hydrant in gallons per minute is easily obtained by using the following formula:

$$Q = av$$

Where:

Q = amount of flow
a = cross-section area of stream
v = velocity of moving stream

The total discharge is the sum of the individual discharges at each flowing hydrant. It is good to know how to use the formula, but the same results can be obtained by using a table containing the answers to various situations already calculated. These tables are contained in the *Fire Protection Handbook.*

Discharge capacity. The capacity of an installation distribution system is usually based on a residual pressure of 10 psi. Therefore, applying the data obtained by the test, the capacity is computed at that pressure by using AF Form 1027, Water Flow Test Record, or the formula. This is the maximum rate at which water can be drawn from the system without reducing the pressure in the system to less than 10 psi. AF Form 1027 is a semilogarithmic scale that has been developed to simplify the process of determining available water in the area. The chart is accurate to a reasonable degree, if one uses a fine-point pencil or pen when plotting results.

Exercises (428):

If one of the following statements is correct, mark it True; if it is False, correct it.

___1. To cope with the available water supply most effectively, you must have a full knowledge of any existing deficiencies in that system.

___2. The primary water supply for an Air Force base should come from a nearby private water company or municipality if at all practical.

___3. A minimum of two wells are required when the source of water supply is wells.

___4. The only true test of pressure for a water supply system is the ability of the outlet to deliver a given number of gallons of water over a certain period of time at 50 psi for firefighting purposes.

___5. You should not test the pressure for firefighting water flow while other users of water are at peak demand.

—— 6. The fire flow test is based on the measurement of pressure at several hydrants.

—— 7. If three hydrants are being used in a fire flow test, the hydrant in the middle of the three is known as the residual hydrant.

—— 8. As a part of the fire flow test, a cap fitted with a pitot tube is placed on the residual hydrant and the hydrant is opened and the pressure is recorded.

—— 9. When measuring the 2½ inch outlets of the test hydrant, the measurement should be made to the nearest one-sixteenth of an inch.

—— 10. With all test hydrants flowing, the pressure of the water flowing out the residual hydrant is the residual pressure.

—— 11. The openings of the flowing hydrants are adjusted so that the pressure at each of these hydrants is at least 10 psi, and the drop in pressure at the residual hydrant is at least 10 psi.

—— 12. If after making a fire flow test, you decide to use the tables containing the answers to the various situations already calculated in place of the Q = av formula, you should go to AFR 92-1 for the correct tables to use.

—— 13. Usually the capacity of an installation distribution system is based on a residual pressure of 10 psi.

—— 14. AF Form 1027 is a scale that has been developed to simplify the process of determining available water in an area, and is accurate to a reasonable degree if used with a fine-point pencil or pen.

429. Point out features of water-supply and distribution systems.

Water Storage. The normal water demand on an Air Force base varies considerably between night and day and for different days of the week. But fire protection needs may have to be met at any time. The capacity of supply lines, wells, or other water sources may not be large enough to meet peak demands. Nor, in most cases, would it be economical to design a system that would provide such capacities. The problem of providing water for peak domestic fire protection needs is solved by providing storage capacities in the supply system. During periods of low consumption, water is placed in storage for use during periods when the demand exceeds the capacity of the source or the supply lines. Storage also enables water to be supplied during emergency conditions resulting from fires, power failures, failure of supply sources, or other conditions that may result from natural causes, accidents, or willful acts. Water is normally stored in three ways: elevated storage, ground storage, and emergency reservoirs.

Elevated storage. This is the storage of water at an elevation above the level of the distribution system to produce adequate working pressures. Elevated storage may consist of tanks on high ground or towers, or it may be open reservoirs on high ground.

Ground storage. This is the storage of water at or near ground level. A pumping station is required to pump water from these tanks directly into the distribution system or to elevated storage of some type to provide working pressures. It is important that the pumps in this sytem have a power supply available—separate from the normal base power supply—that will assure that the pumps will work when needed, regardless of conditions.

Emergency reservoirs. These are small storage facilities which are filled from the distribution systems. Such reservoirs are not designed to supply the distribution systems but are to be held in reserve. They should therefore be equipped with pumper connections or other devices for quick use during emergencies.

Distribution Requirements. In a large water distribution system, the mains are classified as primary feeders (large pipes widely spaced to feed the smaller pipes), secondary feeders (pipes of medium size which aid the supply at specific required locations), and distributors (small mains that feed the individual fire hydrants and other outlets).

The network of mains (feeders and distributors) and fire hydrants that make up the distribution system are laid out in one of two designs, the grid system and the nongrid system.

Grid system. A grid system is laid out in the form of a gridiron. The piping is interconnected from several directions. The term "loop system" is often applied to this type of system, since the piping is arranged in loops and is supplied from two or more sides. This is the most desirable system because it allows hydrants and other connections to be fed from at least two directions, which greatly increases the delivery of water. A full grid system does not have dead-end mains.

Nongrid system. A nongrid system may be considered a one-directional-flow system, where the supply is from a large primary main to smaller feeders. Generally all feeders result in dead ends. Some of the undesirable features of the nongrid system are the increase in friction loss, the quick loss of pressure because of one-direction flow, operation from dead-end feeders, and increased deposits and foreign matter in all the piping.

When a distribution system is laid out, it is important to consider the future development of the base. Plan, in a general way at least, for protection for the ultimate; and then install that part of the system for which there is an immediate need.

The size of the water mains are dependent upon the fire demand, special requirements, and peak domestic demand. All items should be considered; the size of the piping should be such as to satisfy the needs of the greatest possible flow, with consideration being given to needed residual pressure.

Water mains. Water mains are usually made of cast iron and are frequently lined with cement. Water mains should never be less than 6 inches in diameter in low-risk areas and never less than 8 inches in high-risk areas. The distribution system should be interconnected at approximately 700-foot intervals (grid systems) and should contain strategically placed isolation or shutoff valves. These valves are able to segregate unexpected ruptures during emergencies. They prevent the entire system from being placed in a state of disrepair. All mains should be thoroughly flushed as often as necessary through open hydrants to eliminate rust and other scale deposits.

Fire hydrants. Fire hydrants used on Air Force bases should have barrels 6 inches in diameter, with two 2½-inch hose connections and one pumper hose connection (4½-inch streamer connection); all three should contain national standard hose threads. Where freezing occurs, the entire water distribution system and hydrant shutoff valve should be installed well below the frost line.

The location and spacing of hydrants under various types of construction and conditions are defined in AFM 88-10, *Water Supply.* The following requirements have been taken from this publication to serve as general rules for the location and spacing of hydrants. They should be placed:

- About 400 feet apart in housing areas and placed so every building can be reached from two hydrants, with not more than 300 feet of hose.
- About 300 feet apart in warehouse and hangar areas.
- At least 25 feet from buildings.
- At least 6 feet from paved road surfaces.
- Not farther than 7 feet from an approach. When ditches or other conditions interfere with the above spacing, a maximum of 16 feet is permitted between hydrant and the closest approach route.
- At least 3 feet from any obstruction and never directly in front of entrances or driveways:
- At least 18 inches between the lowest hydrant outlet and grade and not more than 4 feet between the operating nut and grade (ground level).
- The principal (4½-inch) opening should face the nearest road or approach.

Hydrants that cannot be located away from traffic, as in loading dock or warehouse areas, should be protected with sturdy barriers designed to prevent damage to the hydrant without obstructing it for fire use.

Fire hydrants should be painted a distinctive color to facilitate day and night identification. The barrels of all five hydrants should be painted with a yellow reflective color, with hydrant numbers in contrasting color. Protective barriers should be painted similar to traffic obstacles. Tops and outlet caps of hydrants should be painted an appropriate color indicating the hydrant's class and flow capacity, as shown below:

Class	*Flow*	*Color*
A	1000 gpm or greater	Green
B	500 to 1000 gpm	Orange
C	Less than 500 gpm	Red

Exercises (429):

1. How is the problem of providing water for peak domestic fire protection needs solved?

2. What are the three ways water is normally stored?

3. Of the three ways of storing water, which one must be supplied with pumps?

4. When your ground storage system must be used for peak fire demand, how can you assure that the pumps will work?

5. In a large water distribution system, how are the small mains that feed individual fire hydrants classified?

6. When laying out a water distribution system, how would you insure that there are no dead-end mains in the system and that the hydrants are fed from at least two directions?

7. Why is there a quick loss of pressure in a nongrid distribution system when a hydrant is opened?

8. Of what size should the water mains be in high-risk areas?

9. If a main ruptured during a major fire, how could you segregate the affected area and still maintain system pressure?

10. The barrels of fire hydrants used on Air Force bases should be how large in diameter?

11. To what standard Air Force publication should you refer for information on the location and spacing of fire hydrants?

12. If the hydrants in a housing area are properly spaced, you should be able to reach any house from two hydrants without using more than how much hose?

13. How close to a building should a hydrant be located?

14. Explain how a hydrant should be located at the intersection of a street and driveway to an industrial shop.

15. Why should hydrant barrels be painted with a yellow reflective color?

16. If you approach a hydrant with its top and outlet caps painted orange, you should expect that hydrant to deliver how many gallons of water per minute?

430. Indicate whether given statements concerning the inspection and maintenance of fire hydrants are correct. If a statement is invalid, correct it.

Fire hydrants are an important part of the installation fire protection system and must be kept in good working order at all times. Mains must be located and checked periodically for leaks. Cleaning of mains and flushing of dead ends are also essential to proper maintenance.

Maintenance of Hydrants. Hydrants can be maintained by replacing all worn or malfunctioning parts and seats through the top of the hydrant. Many hydrants require special wrenches or fittings to withdraw the lower parts. Proper tools should be obtained for every type of hydrant on the installation.

Manufacturer's data. The variety of makes and models of fire hydrants necessitates listing data for each different type or make of hydrant on the base. Descriptive matter and operating and repair instructions should be obtained from manufacturers and filed for quick reference.

Inspection and service. The following inspections should be accomplished at least annually. Start inspection at hydrant nearest source of supply. Locate nearest valves on hydrant stub or grid system so they can be shut off if hydrant is found defective during inspection. Remove one hydrant cap and replace with cap fitted with pressure gage. Open hydrant SLOWLY until wide open. With the hydrant open, do the following:

(1) Check tightness of male connectors (nozzles). Inspect at point where nozzles enter hydrant barrel. Calk head around nozzles when necessary.

(2) Check for leakage in top of hydrant. If necessary, remove cover, tighten packing gland, or repack.

(3) Check for leakage past gaskets under other caps. Replace defective gaskets.

(4) Check for cracks in barrel. Order installation of new barrel or hydrant when required.

(5) Look for leakage through drain valve. Valve should be closed when hydrant is wide open. When necessary, replace drain-valve facing or gasket if water comes out of drain or up around hydrant when hydrant valve is wide open.

(6) Check static pressure. Record pressure shown by pressure gage. Close hydrant valve.

(7) Determine residual pressure. Remove second hydrant cap, leaving pressure gage in position; open hydrant valve slowly until wide open; read and record residual pressure on gage when hydrant is discharging maximum stream. Allow flushing to continue until discharge is clean.

CLOSE HYDRANT SLOWLY, then do the following:

(1) Check tightness of valve and seat. Watch lowering of water level in hydrant after valve is closed. If level does not drop, listen with ear against hydrant. If noise is heard, main hydrant valve is probably leaking and must be replaced. If water is quiet, drain valve is fouled and must be opened.

(2) Inspect operating nut. Replace if it has rounded corners caused by improper wrench.

(3) Inspect nozzle threads. Replace nozzle if threads are badly damaged.

(4) Check chains. If paint has frozen chains tight to caps, chip out paint to free chain. Replace lost chains only when required by directives on fire protection.

(5) Lubricate operating nut. Remove screw in top of operating nut and apply oil, grease, or graphite grease recommended by manufacturer. If hydrant does not operate freely after lubrication, lubricate packing and thrust collar by oiling joint between nut and collar.

(6) Record flow from hydrant. To determine capacity of flow, use residual-pressure readings. Decidedly low flow indicates that valve mechanism is out of order and must be repaired. Compare results with data from previous tests to see whether there has been any decrease in distribution system carrying capacity. If the concurrent gate-valve inspection does not reveal closed valves, a thorough flow-capacity determination of the system may be required. Approval of higher authority should normally be obtained for such a study.

Checking in Freezing Weather. In subzero weather, inspect hydrants near important structures weekly; inspect other hydrants monthly. Do not flush hydrants on such inspections. During inspection, do the following:

(1) Place operating wrench on nut and turn slightly to make sure it is not frozen. If frozen, thaw by using blow torch on operating nut.

(2) Remove hydrant cap and inspect for ice in barrel by lowering small weight on string. If hydrant contains ice, thaw by one of the following methods:

(a) Inject live steam from portable steam thawer.

(b) Put in a few aluminum chips mixed with a double amount of caustic soda chips and pour in about a cup of water. The heat which is thus generated will thaw out hydrant barrel in 10 to 20 minutes. Remove hydrant caps to allow generated gas to escape.

(c) Build small bonfire around hydrant.

(3) After ice is thawed enough to allow opening hydrant, flush slowly until all ice is melted.

If hydrant barrel does not drain, pump out all water and fill with salt.

When fire hydrants are out of service, the civil engineer plumbing shop identifies them with a metal placard no less than 12 inches in diameter. These placards will have a red backing inscribed with "OUT OF SERVICE" in white weatherproof letters. One placard will be attached to the hydrant at each 2½-inch outlet and held in place by the outlet cap.

Exercises (430):

If one of the following statements is correct, mark it True; if it is False, correct it.

___ 1. All worn or malfunctioning parts and seats of a fire hydrant can be maintained through the 4½-inch pumper connection cap.

___ 2. A full set of the manufacturer's descriptive matter and operating and repair instructions should be obtained and filed for each make and model of fire hydrant on base.

___ 3. The male connections on a hydrant should be inspected at the point where they enter the hydrant barrel at least once each year.

___ 4. If water comes up around the hydrant when the hydrant valve is wide open, the cause will most likely be a defective nozzle seat.

___ 5. If after you shut a hydrant down and the water level in the hydrant barrel does not drop, you should listen with your ear against the hydrant; if a noise is heard, you should suspect a leaking main hydrant valve.

___ 6. If the hydrant does not operate freely after lubrication has been applied through the screw hole in the operating nut, the nut must be replaced and relubricated.

___ 7. Hydrants near important structures should be inspected monthly during subzero weather.

___ 8. Hydrants may be thawed out by using a blow torch on the operating nut.

___ 9. You can thaw a hydrant out in 10 to 20 minutes by using a mixture of two parts caustic soda chips to one part aluminum chips mixed with a small amount of water.

CHAPTER 4

Fire Hazards

A CONTINUOUS inspection program is necessary if we are to assure compliance with fire regulations. It can eliminate conditions that contribute to fire hazards. Thorough inspections must be made by qualified fire department personnel of each building, structure, process, activity, and area at regular intervals. Such inspections should lead to the prompt correction of physical fire hazards that may not be noticed by untrained personnel, and of other hazards that arise from carelessness or incorrect procedures. The continuing reliability of fire protection equipment and devices is too important to be taken for granted. Frequent inspections are necessary if we are to be sure that such installed and portable equipment is properly installed or located, maintained and ready.

4-1. Fire Inspections

As a fire protection specialist, you know that one of your many duties will be fire inspection. Knowing what to inspect for and how to inspect while complying with all directives is an essential part of the total fire inspections.

431. Cite the general purposes of conducting fire inspections.

Before we get too far, we should state why we have fire inspections. In this way everyone will get pointed down the same road.

Purposes of Fire Inspections. The inspection routine of fire protection personnel has six general purposes:

(1) The detection and correction of all fire hazards which constitute a problem and which frequently pass unnoticed by all except trained individuals.

(2) The testing and visual inspection of all fire alarm and extinguishment equipment, such as sprinkler systems, alarm systems, hydrants standpipe systems, and water supply systems.

(3) The inspection of all first-aid fire extinguishers and appliances to determine if they are properly located and maintained, and the correction of any fault that would prevent such equipment from being operated immediately when needed.

(4) The familiarization of the location, condition, and arrangement of buildings so that, if a fire occurs, firefighting personnel will be able to move efficiently and safely.

(5) The monitoring of adequacy and practice (display) of preplanned emergency action and evacuation procedures.

(6) The identification of special fire-hazard occupancy areas.

If fire prevention is to be successful, these inspections and corrections must be rigidly enforced. Now that we know why we have fire inspections, the next logical step is to find out how often these inspections should be made.

Exercises (431):

1. As a fire inspector, your inspection routine will have how many general purposes?

2. Why should trained personnel conduct fire inspections?

3. During a fire inspection, what are the fire extinguishers within the building checked for?

4. Why should fire inspectors maintain a familiarization of the location, condition, and arrangement of buildings?

5. What must be done if fire prevention is to be successful?

432. State the frequency at which fire inspections should be made and cite classes of fire hazards.

Frequency of Fire Inspections. The frequency of fire inspections will vary, depending upon the nature and complexity of the facility, degree of fire hazard potential, type of operations, and personal habits. The following information can be a guideline for the frequency of fire inspections conducted by fire department personnel, but may be altered for local use. (The inspection intervals suggested below do not relieve commanders, supervisors, etc., from their fire prevention responsibilities.)

Flight line, fuel-handling operations, fuel-cell maintenance, vulnerable missile operations, special hazardous processes, etc., should be under constant spot-check surveillance, with inspections on a weekly to monthly basis.

Storage, normal maintenance, shop, industrial, laboratory, hospital, club, food preparation, group assembly, school, nursery, and similar occupancies should be inspected monthly.

Administration, community, and dormitory occupancies normally require quarterly inspection, except where conditions warrant more frequent observation.

Air Force-sponsored family housing, regardless of location, should be inspected as requested by the occupant. Occupants should be thoroughly and continuously indoctrinated in fire prevention. Particularly must we remind them of the danger of careless smoking habits and of the danger of allowing children to play with matches. In the past, fires in family housing caused by carelessness have been the most tragic. Also, it may be advantageous to sponsor voluntary fire inspection of private housing occupied by Air Force personnel.

Classes of Hazards. Another guideline which can be used in regard to the frequency of fire inspections is the segregation and separation of fire hazards. Under this concept, a fire hazard is defined as a condition or conditions favoring destruction of life or property by fire. Such hazards may be grouped in accordance with their potential destructiveness into these classes: *target hazards*, *conflagration hazards*, *common hazards*, and *multiple-unit family housing.*

Each of these types of fire hazards presents a different kind of problem to the fire protection specialist. The division of these hazards into classes is convenient, as differentiating between them may be used as a basis for the frequency of inspections.

Target. Target hazards are those in which a fire would have the potential of involving a possible large life loss, destroying large concentrations of materials of high monetary value, or involvement of a large concentration of rapid-burning materials. These hazards are represented by such areas as theaters, hospitals, schools, fuel storage, lumber yards, commissaries, and base exchange facilities.

Conflagration. From a fire protection standpoint, conflagration hazards are those where the fire potential could be the uncontrolled involvement of two or more buildings and the possibility of spreading to other areas. This condition may exist where there is a considerable number of closely built combustible buildings, or a grouping of buildings using hazardous occupancies or processes.

There is generally more than one contributing factor in a conflagration hazard. The most prominent among these factors are high winds, wood shingle roofs, inadequacy of water distribution systems, or the distance that the areas may be located from adequate fire protection.

Special. Special fire hazards involve the processes or operations peculiar to an individual building or area. Special hazards are those commonly referred to as "hot spots." They must be given individual attention, for usually surrounding areas are endangered as well as the particular property on which special hazards are found. "Hot spots" include such hazards as volatile flammable liquids stored in congested or semicongested areas and multistoried buildings without adequate fire escapes.

With buildings constantly increasing in size and value and the resulting increase of new fire hazards, scientific study of these new conditions becomes necessary as they develop.

Common. Common fire hazards are the most universally found of the four types. The buildings and areas of this group will make up the bulk of your base, and therefore the bulk of your inspection work. A building that presents no major fire protection problem, such as those explained in the previous paragraphs, is classed as a common hazard.

Multiple-unit family housing. The common-use areas such as hallways, stairways, boiler rooms, and storage areas, etc., will be inspected annually.

Exercises (432):

1. The frequency of fire inspections will vary depending upon what?

2. How often should fuel-cell maintenance areas be inspected?

3. After the initial orientation, how often should Air Force-sponsored multiple-unit family housing be inspected?

4. Fire hazards are grouped into four classes according to what factor?

5. What are the four classes of fire hazards?

6. A lumber yard would be classed as what hazard?

7. Which of the classes of hazards is the most universally found?

4-2. Fire Hazard Control

For the time being, we will consider that fire hazard control begins when the fire inspector makes his inspections of the various buildings and areas. So, first of all, let's take a look at the fire inspector himself.

To be a proficient fire inspector, which every experienced fire protection specialist should be, you must have a basic knowledge of chemistry, mathematics, physics, and architectural and construction principles, as well as a wide background in firefighting. Along with these qualifications, the ideal fire inspector should be exceptionally observant, diplomatic yet forceful, and conscientious. If you have all these skills, you should be able to detect all existing fire hazards and see to it that they are promptly corrected.

The value of a fire inspection depends primarily on the competence of the inspector, his familiarity with the conditions he is inspecting, and his thoroughness. The inspector must have a sense of the relative importance of hazard conditions and be constructive and cooperative rather than merely critical. The purpose of a fire inspection is to eliminate fire hazards, not merely to uncover discrepancies. The inspector should always be neat in appearance, courteous, and helpful, but *firm* in pointing out, correcting, and/or reporting hazardous conditions. In doing his important job conscientiously, the inspector will impress on others the vital seriousness of fire prevention. Now let's take a brief look at several fire hazards and what you, as an inspector, should look for as you are inspecting the different buildings and areas.

433. Point out hazards associated with smoking materials and show ways in which the hazards may be controlled.

Cigarettes and Matches. Because so many people indulge in the habit and because they frequently use matches to light their cigarettes, smoking is one of the greatest single causes of fires. This condition does not appear serious to most laymen because the great majority of them have never started a fire by smoking—that is, one that they know of. Actually, anyone who has carelessly discarded a lighted cigarette may be guilty of having started a fire, even though the cigarette may have been dropped upon concrete, metal, or barren earth. Paper, having a low flashpoint, is extremely susceptible to ignition by a lighted cigarette. It is therefore foolish to empty ashtrays into a wastepaper container, even though the cigarette butts apparently are not smoldering.

Any type of match may start a fire, but the possibility of its doing so varies greatly according to the type of match. The proper safety match has a head that will not fly off when struck, and a stick that is treated to eliminate afterglow. The use of good safety matches should be required in all approved smoking areas.

Smoking or other sources of ignition should be prohibited in areas in which a match, flame, spark, or careless disposal of smoking material would constitute a serious hazard. Where complete prohibition of smoking is impracticable, designated areas should be provided. Such areas must be clearly marked and separated from hazardous areas to preclude the possibility of fire. Smoking area signs should be displayed, and noncombustible disposal receptacles for discarded smoking material provided.

Exercises (433):

1. Why is it foolish to empty ashtrays into wastepaper containers?

2. The possibility of a match starting a fire varies greatly according to what factor?

3. How does the proper design of safety matches help reduce the starting of unintentional fires?

4. In areas where the complete prohibition of smoking is impracticable, what action should be taken to reduce the hazards from smoking?

5. Designated smoking areas should be provided with what items?

434. Cite hazards associated with waste and rubbish and list means of control of the hazards.

Waste and Rubbish. Waste materials and rubbish are great contributors to fire propagation. When in contact with oils containing spontaneous-ignition characteristics, waste materials may not only be responsible for fire propagation but may also be the very source of the fire. A high standard of cleanliness and the complete elimination of loose rubbish from building interiors are unquestionably among the greatest factors of fire prevention. It is the duty not only of fire inspection personnel but also of *all* personnel occupying the building to see that poor housekeeping habits are eliminated.

When it is impossible or very inconvenient to remove flammable rubbish from the building immediately, these materials should be kept in fire-proof or fire-resistive containers or enclosures. Buildings containing highly flammable material should be sprinkler equipped.

Clean waste, although not as hazardous as used or reclaimed waste, has occasionally been reported as a source of spontaneous ignition. Consequently, all waste, excelsior, straw, sawdust, and burlap should be kept in metal tins with self-closing covers to prevent the admission of oxygen in the event that sufficient internal heat is generated to cause fire.

Spontaneous ignition occurs under extremely variable conditions. It is difficult to state that a specific quantity of flammable materials will or will not ignite independently of external heat, since the naked eye cannot see all of the contents of the material, and the time factor required for ignition may range from minutes to months.

Exercises (434):

1. When may waste materials most likely be the very source of a fire?

2. What are the greatest factors of fire prevention in association with waste and rubbish?

3. Besides the fire inspector, whose duty is it to see that poor housekeeping habits are eliminated?

4. If, for one reason or another, flammable rubbish cannot be removed from a building, what precautions should be taken to minimize the hazard of fire?

5. Why should all waste, excelsior, straw, sawdust, and burlap be kept in metal tins with self-closing covers?

435. Complete statements concerning hazards associated with electricity in general.

Hazards of Electricity. Electricity, if improperly used, may easily become a major fire hazard and a serious source of danger to personnel. When the simple and proper rules of installation and use are adhered to, electricity is a superior source of power, illumination, and heating.

Electricity may become a fire hazard by overheating, arcing; or sparking. Overheating is a condition in which an overload of electrical current is passed through a wire and the internal heat created by the overload ignites the insulation covering the wire. This insulation then ignites adjacent combustibles. When an electric motor is overworked or defective, it overheats, and fire results. A single electrical outlet or wire used as a power supply for too-many electrical implements will cause overheating. Arcing is a sustained luminous glow which is formed under certain conditions when a break is made in an electric circuit. An arc light and the breaker points in an automotive distributor system are examples of arcing. Sparking is an electrical condition in which light is created, accompanied by a sudden disruptive discharge, between two conductors separated by air or some similar medium. The action of spark plugs in an internal combustion engine is an example of sparking.

Minimizing the Hazard. To minimize these hazards from electrical sources, the equipment and system of installation should be standardized and properly maintained. It is the job of fire inspection personnel to see that these hazards are completely eliminated. Being certain that no fires will start from an electrical source today gives us no assurance of fire safety next week. Inspectors unable to visit each building daily must help to educate the occupants on what constitutes a fire hazard.

Electrical installations are made in accordance with national electrical codes, state laws, and municipal ordinances. If these provisions are followed, fire hazards are *decreased* but certainly not *eliminated.* Deterioration by use, abuse, and age often requires the replacement of electrical wires and their associated implements. Frequently, crude installations and use of electrical fixtures by the layman make for flagrant violations of fire safety rules.

Electrical circuits carry currents of varied intensity. When current is suddenly cut off, whether by accident—such as by a loosened contact at a terminal—or by intention, an arc is produced. The magnitude of this arc depends upon the current and amount of voltage involved. At all times the temperature of this arc is very high, and it is capable of igniting combustible materials. In addition, the metal of the conductor will sometimes fuse. This hot, flying metal, along with the flying sparks, may also ignite combustibles and frequently causes the ignition of wire insulation.

The electric wire, or "conductor" as it is technically termed, is normally a negligible consideration from the standpoint of overheating. However, there is a possibility of overloading, for each conductor is rated with a certain maximum capacity. Fire hazards occur in two ways when this capacity limitation is exceeded: through the deterioration of the insulation (thus exposing the wire) and through the creation of excessive heat.

Exercises (435):

Fill in the blanks in the following statements.

1. The three ways in which electricity may become a fire hazard are ______________, __________, or __________.
2. A condition in which an overload of electrical current is passed through a wire and the internal heat created by the overload ignites the insulation covering the wire, which in turn ignites adjacent combustible material, is known as ________
3. __________ is an electrical condition in which light is created, accompanied by a sudden disruptive discharge, between two conductors separated by air or some similar medium.
4. To minimize the hazards from electrical sources, the equipment and system of an installation should be ______________ and __________ __________.
5. The replacement of electrical wires and their associated implements is often required as a result of deterioration by _____, __________, and __________.
6. The magnitude of the arc caused when electrical current is suddenly cut off depends upon the __________ and ________ __________ __________ involved.
7. When overloading occurs, the conductor has exceeded its __________ __________.

436. Ascertain the validity of statements concerning fuses and other electrical safety devices. If a statement is invalid, correct it.

Fuses and Other Safety Devices. Many devices have been designed to give overcurrent protection. These devices open the circuit and cut off the current when the electrical flow reaches a given maximum. The most common of these devices is the fuse, which contains a strip of metal that overheats and melts when the current exceeds the fuse capacity, thus opening the circuit.

Another protection against overcurrent is provided by the circuit breaker. It may be of the electromagnetic or thermal (bimetal) type. Largely because of the cost, the thermal type of circuit breaker is more commonly used. However, since the electromagnetic type is more sensitive and faster acting, it is used when the overload factor must be held to very close limits.

All current protective devices must be designed to confine the arc harmlessly within themselves when they go into operation. Fuses consist normally of two common types, the plug type and the cartridge type. Clean contacts at the fuse terminals or boxes are important because dirt can cause overheating and blowing of fuses.

The hazards most likely to be found in overcurrent protective devices are as follows: (1) plug fuses which have blown out and have pennies inserted behind them or wires inserted between the broken contacts; (2) fuses of a capacity higher than desirable, or circuit breakers with too high a setting; (3) fuses or circuit breakers in poor mechanical condition; (4) unconfined fuses in an area containing combustible material; (5) fuse cabinets with open or missing doors; (6) corroded fuses, inclosures, or circuit breakers; (7) refillable fuses containing additional metal strips; (8) cartridge fuses which have been blown and replaced with nails, wires, or other metal; and (9) circuit breakers rendered useless by the tying or blocking of the tripping element.

Exercises (436):

If one of the following statements is correct, mark it True; if it is False, correct it.

____1. Basically the electrical safety devices close the circuit and cut off the current when the electrical flow reaches a given maximum.

____2. The thermal (bimetal) type circuit breaker is the more commonly used type, largely because of the cost.

____3. Of the two types of circuit breakers discussed, the thermal type is used when the overload factor must be held to very close limits as it is more sensitive and faster acting.

____4. Regardless of what type current protection device is used, they must all be designed to confine the arc that results from their operation within themselves.

____5. Overheating and blowing of fuses may be the result of dirt on the contacts at the fuse terminals or boxes.

____6. One of the many hazards often found is the practice of inserting wires between the broken contacts on plug fuses.

____7. When circuit breakers are used in a circuit designed for 15 amp use, a breaker of 25 amps should be used.

____8. Circuit breakers are often rendered useless by blocking or tying the tripping element.

437. Complete statements concerning hazards associated with wiring, switches, and flexible cords.

Wiring and Switches. There are several recognized methods of installing wiring. Only rigid conduits should be used where fuel vapors may be present, as in a hangar. No conductor should be installed, even temporarily, that does not conform to all safety requirements.

The hazards most frequently found in electrical wiring are as follows: (1) overloaded conductors; (2) corrosion of conductor coverings; (3) corrosion and loosening of supports; (4) covers of outlet boxes or junction boxes removed; (5) conductors of open wiring systems separated from their supports and in contact with other conductors or combustible material; (6) deteriorated conductor insulation due to age, injury, heat, vapors, or moisture; (7) wiring installed for temporary use; (8) wire joints not properly put together; and (9) flexible conductors hung over nails or other makeshift contrivances which may cause wear and thus create arcing or sparking.

The chief hazard of electrical switches is the occurrence of arcing when the switch is operated. Switches should have an inclosure that will harmlessly confine any arc. The most prominent hazards in switches are corrosion, faulty mechanical condition resulting from use or abuse, overheating that is caused by poor contact or by an overload of current, inclosures absent or ineffective, and contacts burned or pitted where the circuit is opened or closed.

Flexible Cords. Flexible cords should be used only when absolutely necessary, for their use constitutes a distinct fire hazard unless careful attention is given to their treatment and condition. Flexible, portable cords are subject to much abuse. They contain a conductor made of fine strands of wire, with an insulating covering of small dimension which frequently consists of combustible materials. Instances have occurred when metal-wheeled vehicles have passed over portable, flexible cords in hangar areas and caused critical losses by creating an arc in the presence of fuel vapors. A cord should be *lifted over* any heavy moving object; do *not* allow the object to pass over the cord. The better portable cords are covered with a heavy rubber outer jacket. Constant observation and maintenance of these cords is a paramount safety precaution. Complete replacement of a cord is necessary when appreciable wear becomes evident.

Exercises (437):

Fill in the blanks in the following statements.

1. Where fuel vapors are present, electrical wiring should be installed in ____________ ____________.
2. All conductors, even temporary ones, should be installed to conform to all ______ ____________.
3. The chief hazard of electrical switches is the occurrence of ____________ which takes place when the switch is operated.
4. Of the most prominent hazards encountered in electrical switches, one is overheating due to ________ __________ or an ______ ______ ______.
5. The use of flexible cords constitutes a distinct hazard unless careful attention is given to their treatment and condition, therefore, they should be used only when __________ __________.
6. When a portable, flexible electrical cord is used, it should be __________ __________ any moving object.
7. When appreciable wear becomes evident in a portable, flexible electric cord, __________ __________ of the cord is necessary.

438. Point out hazards associated with lamps, electric motors, and generators.

Lamps. The principal types of lamps are vapor, incandescent, and arc. In locations where flammable gases, vapors, or dust are present, the improperly equipped lamp becomes an explosion and fire hazard. Mercury arc lamps are a spark hazard if not confined. The gas-filled lamps now in common use generate sufficient heat to ignite combustibles in contact with, or close to, the globe. Neon lamps require a high-voltage supply and offer a hazard from the arcing which this high voltage may create. Portable lamps are frequently used in damp or wet locations. This practice presents both a fire hazard and a personal safety hazard.

The hazards most common in portable lamps are fragile sockets, the use of defective or unapproved cords, the use of frail lamp guards or the absence of any guard, and the failure to provide a disconnection release in the event of strain on the cord. Lamp sockets are not great fire hazards if an approved type of socket containing the correct load limit is used and if the component socket parts are properly assembled.

There are many lamps that are of substandard construction. When making an inspection of living quarters, inspect these lamps carefully. A substandard lamp is a definite fire hazard.

Motors and Generators. Electric motors and generators present a definite fire hazard, since they are capable of producing arcs or sparks and can overheat and burn out because of overload. The motor frame should be suitably inclosed. Combustible material should be kept away from the vicinity of motors and generators to prevent hazardous conditions resulting from arcing and sparking. Overcurrent protection will safeguard against overloading.

The fire hazards most common with electric motors are as follows: proximity to combustible materials; dampness, which subjects the motor to corrosive vapors; improper overcurrent protection which should not exceed 25 percent of its rated capacity; dirt, such as lint and dust, on top of the motor; the producing of arcs and heat when motors are started in the vicinity of combustible material; burning out because of low voltage at the terminals; and overloading.

Exercises (438):

1. What hazard do mercury arc lamps present if they are not confined?
2. How do the gas-filled lamps now in common use become a fire hazard?
3. What kind of lamps in living quarters present a definite fire hazard?
4. How may electric motors be safeguarded against overloading?
5. Overcurrent protection in electric motors should not exceed what percent of its rated capacity?

439. Explain how static electricity becomes a hazard and describe its elimination.

Static Electricity. Static electricity is generated to an appreciable extent in many industrial and manufacturing operations. It requires major consideration when aircraft are used. Previously it was believed that static electricity was generated only by *friction* between two unlike substances. It is now known that static electricity is created by *contact* between two unlike substances, even though no friction is present. Static electricity is known to be a serious fire and explosion hazard in the presence of volatile flammable liquid, flammable gases, highly ignitible fibers, and combustible dusts.

In areas where the hazard is great, it is advisable to replace belts with chains and gear drives to reduce the generation of static electricity. When the construction features cannot be changed to reduce the generation of static electricity, it is advisable to ground all metal parts which may accumulate an electrical charge. The atmosphere normally is a nonconductor of electricity, but ionized air will normally draw static electricity from charged metal implements. Static neutralizers may be installed to draw these charges.

Humidity is an important factor in the ability of static electricity to drain from highly charged metal objects. Where high humidity is present, surface resistance is reduced, and electrical charges are drained off almost as they form. A humidity of 40 to 50 percent generally prevents any quantitative buildup of static electricity.

Static electricity is created when gasoline or similar flammable liquids are passed through a hose, poured from one container to another, filtered, or subjected to velocity in almost any manner. These dangerous static charges frequently cause serious fires and explosions unless preventive measures are taken.

When gasoline is discharged through a hose, a copper wire should be installed from the pump through the hose to the nozzle, and the nozzle should be kept in contact with the metal receptacle at all times. In many containers such as aircraft tanks, a separate wire with a male connection is plugged into a static electricity drain installed near the tank opening. This device should be plugged in before the gasoline is allowed to flow through the hose.

Elimination. Since static electricity is generated by many common actions and since it is impossible to prevent its generation, it becomes necessary to prevent static electricity from accumulating. This is done by grounding. When you prevent the accumulation, you remove the fire hazard of static electricity.

Exercises (439):

1. How is static electricity generated?
2. Static electricity is known to be a serious fire hazard when?
3. How may static electricity be reduced in drive assemblies?
4. What should be done with metal parts that may accumulate an electrical charge?
5. What may be done to draw charges away from metal implements?
6. Any quantitive buildup of static electricity may be prevented by a humidity of what percent?
7. How is static electricity prevented from accumulating?
8. How do you remove the fire hazard of static electricity?

440. Explain how lightning becomes a hazard and measures taken to minimize the hazard.

Lightning. Lightning is a discharge of atmospheric electricity and a frequent cause of fires. At certain periods in past years, fires caused by lightning led the field from the standpoint of monetary losses. On airbases, where there are wooden structures, flammable liquids, and ammunition powder, precautions against lightning must be taken. This is especially true in the sections of the United States where lightning hazard is present for almost 100 days each year.

Minimizing the hazard. To prevent damage from lightning, it is advisable to run a conductor—such as a metal water pipe or copper plate—from the uppermost part of a structure down into the ground. The arresting terminals should be made of a durable metal, preferably copper, and must be distributed to the extremes of a building; they should protrude 10 to 60 inches above the highest points of the building.

All oil tanks, whether of steel or some other material, should be grounded. Direct lightning strikes (a main hazard of lightning) to tanks may be averted by a network of wires, properly grounded, at least 6 feet above the tanks. A series of steel masts may be erected around the entire tank farm at such a height that they will not impede ground activity. The masts may then be joined with a series of wires which form a horizontal pattern.

Structures containing stored explosives need protection not only against direct lightning hits but also against induced sparks, especially in view of the fact that if ignition occurs, the resulting catastrophe is immediate and of great violence. The best location for powder storage is underground or in small, individually segrated rooms. These rooms should be covered with earth and equipped with copper cables running across the roof and should be grounded on each side.

Exercises (440):

1. What is lightning?

2. How may damage from lightning be prevented?

3. How far above buildings should lightning arresting terminals extend?

4. What is a main hazard of lightning?

441. Given a series of incomplete statements concerning fire hazards associated with buildings in general and measures taken to control them, complete the statements by filling in the correct word(s) and/or phrase(s).

Buildings. The great majority of ordinary buildings contain hazards which should be eliminated. Vertical openings may be protected by the installation of proper doors, walls, or fireproof covers. Walls covered with flammable paint should be treated in places where fire propagation could result in extensive damage. Exposed buildings should have protection for wall openings. Combustible exterior construction and attachments to exposed buildings should be eliminated, if possible, or treated with caution for fire hazard possibilities.

The fire inspector should check wooden floors for thin flooring, cracks between boards, or any openings caused by shrinkage. Each floor should form a barrier which will prevent, or at least impede, the vertical spread of fire for the maximum possible time. This is impossible if there are any openings at all in the floor.

The horizontal spread of fires may be prevented by dividing the interior of buildings into smaller compartments by means of fire-resistive partitions or walls.

Furniture and fixtures are an important item on the fire inspector's checklist; many so-called fireproof buildings have been destroyed because of their combustible *contents.* This shows the reason for the installation of sprinkler systems even in buildings constructed of steel and concrete. Frequently, heavy timber has proved superior to unprotected steel beams in intense heat and prolonged fire. It may endure longer and is less likely to need replacement.

Wooden-shingle roofs are the greatest single contributing factor to conflagrations. They may readily ignite from sparks, especially if the shingles are old and dry. Shingle roofs are not normally found on airbase structures, but where they do exist, the fire-protection organization should be fully aware that they are a fire hazard.

The most effective fire doors are so arranged that when the temperature in the vicinity of one reaches a given point, a special fusible link or thermostatic device is severed, causing the door to slide closed from the gravitational force of its own weight. If one of these fusible links should be broken, it must not be replaced with a substitute simply for the purpose of keeping the door in an open position. Perfect operation of a fire door must

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be *assured* at all times. Normally, fire doors are used to protect openings of vertical shafts and in walls which divide one building or compartment from another. However, it has occasionally been necessary to install fire doors on exterior openings, making it necessary to use other exterior doors as fire exits. If fire doors are well-constructed, with lock-jointed metal covering, they will efficiently serve their purpose. If one door is hung on each side of the wall, effective air space insulation is allowed between the two doors. Fire doors must have a metal exterior if they are to be effective. Doors must be visually inspected and operationally checked for damage by accident or corrosion and for ease of movement; presence of fusible link; general deterioration; and the elimination of dirt, dust, and other foreign elements from all working parts.

Exercises (441):

Fill in the blanks in the following statements.

1. If possible, combustible exterior construction and attachments to exposed buildings should be____________.
2. A fire inspector should check wooden floors for conditions which fail to_________, or at least____________the vertical spread of fire for the maximum period of time.
3. By dividing the interior of buildings into smaller compartments by means of fire-resistive partitions or walls, the__________ spread of fire may be prevented.
4. Because of their combustible____________, many so-called fireproof buildings have been destroyed.
5. The greatest single contributing factor to conflagrations is____________ - ____________ ____________; the reason for this being that they readily ignite from ____________.
6. If operating properly, a fire door will slide closed from the __________ ____________ of its__________ __________when a fusible link or thermostatic device is severed.
7. Normally, fire doors are used to protect openings of____________ __________and in __________which divide one building or compartment from another.
8. If one fire door is hung on each side of a wall, an effective____________ ____________ ____________is allowed between the two doors.

442. Indicate whether given statements concerning heating systems are correct. If a statement is invalid, correct it.

Heating Systems. Heating systems are a common source of fire during winter seasons in most latitudes. Heating units and their conditions of installation are so varied that it is impossible to deal with each specific hazard in detail here. The best procedure is to inspect each heating system while it is inoperative and also while it is in various phases of operation, and then take the necessary action to eliminate hazards.

We must realize that any source of heat is a potential fire hazard unless it is so constructed and installed that it will not heat adjacent combustible materials to a point where they may ignite. Heating devices, for a proper margin of safety, should be so installed that exposed woodwork will not be heated in excess of 160° F. Normally, building codes require that heating units and their conveying ducts be installed a given minimum distance from combustible materials. This condition seems somewhat unimportant if we do not take the ventilation and circulation aspects into consideration.

Insulation alone is not a solution to safe heating. Heat from a stove base, for example, has been known to penetrate metal, brick, and asbestos and to char the wood beneath when these materials have no airspace below them. In large rooms, a reasonable clearance between the heating device and the combustible material is the primary requisite. In small rooms, however, where circulation is poor, clearance and insulation may not be adequate to prevent the ignition of combustibles. Long-continued high temperatures have been known to cause fires under apparently safe conditions. This indicates that heat consistency and quantity must be carefully considered during inspections.

Stationary heating devices are rated in three grades: low, medium, and high. Low-grade furnaces develop temperatures up to 600° F and require 4 feet of frontal clearance, 1½ feet on the rear and sides and 1½ feet of overhead clearance. Medium-grade furnaces develop temperatures from 600° to 1500° F and require 8 feet of frontal clearance, 3 feet on the rear and sides and 4 feet of overhead clearance. High-grade furnaces create temperatures in excess of 1500° F and require a minimum of 30 feet of frontal clearance, 10 feet on the rear and sides and 15 feet of overhead clearance.

Steampipes of any type may, in the course of time, make charcoal out of wood with which they are in contact. This charcoal is subject to spontaneous ignition because it absorbs great quantities of oxygen from the atmosphere. Steampipes should be wrapped with asbestos or magnesia insulation. The wrapped pipe must

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have a minimum of 1 inch of clearance from all woodwork.

Massive ranges and ventilating systems present great hazards in dining halls and other locations where food is prepared for large groups. Hot grease boiling over containers, the residue in the hoods, the area over the range, and the space within the ducts leading away from the hoods are the chief sources of fire danger. Ducts should be made of not less than No. 20 U.S. gage steel, tightly riveted at the joints, so that if the grease residue ignites and burns, there will be a minimum of damage to the building itself.

Coal and wood stoves should be mounted on fire-resistive floor, and should follow the clearance and ventilating requirements of a low-grade furnace. They should be mounted on legs, which keep them off the floor. The stovepipes must be properly installed and must not pass through confined spaces in which an ignition temperature could build up. Stovepipes should be properly supported, kept in good repair, and cleaned regularly.

Exercises (442):

If one of the following statements is correct, mark it True; if it is False, correct it.

____1. The best procedure to use when inspecting heating systems is to inspect them while they are inoperative and also while in various phases of operation.

____2. For a proper margin of safety, heating systems should be so installed that exposed woodwork will not be heated in excess of 235° F.

____3. When the ventilation and circulation aspects are not taken into consideration, insulation alone is a solution to safe heating.

____4. Heat consistency and quantity must be carefully considered during inspections as evidenced by the fact that long-contained high temperatures have been known to cause fires under apparently safe conditions.

____5. Stationary heating devices are rated in four grades; low, medium, high, and very high.

____6. Low-grade furnaces develop temperatures up to 600° F and require 48 inches of frontal clearance and 18 inches of rear, side, and overhead clearance.

____7. High-grade furnaces create temperatures in excess of 1500° F and require a minimum frontal clearance of 30 feet, while medium-grade furnaces require 8 feet of frontal clearance as they develop temperatures from 600° F to 1500° F.

____8. Wood which in the course of time has been made into charcoal due to contact with steampipes is subject to spontaneous ignition because it absorbs great quantities of oxygen from the atmosphere.

____9. Steam pipes wrapped with asbestos insulation must have a minimum of 1 inch of clearance from all building materials.

____10. In dining halls the ducts leading away from the range hoods should be made of not less than No. 28 U.S. gage steel, with the joints tightly riveted.

443. Complete statements concerning hazards associated with buildings under construction and the measures taken to minimize them.

Buildings Under Construction. Buildings in their various stages of construction usually offer more fire hazards than they do after they are completed. Perhaps people find it hard to visualize a building burning down completely before it is put up completely. There is, therefore, usually no fire-extinguishing equipment immediately available. On an airbase, construction operations are common. The loss of any of these projects by fire, regardless of the stage of completion, may cause severe hardships and serious delays. For this reason it is recommended that first-aid free extinguishers be made available in proper quantity and be adequately distributed throughout the project.

In tall buildings the standpipe system should be set up within the building in anticipation of a fire at any level where flammable materials are present. All form lumber and other excess wood should be removed promptly. Heaters and heating equipment should be strong and safe. They should be located where they will not ignite other material, and they must be constantly attended.

Combustible materials should not be stored in or near buildings under construction. Gasoline and other volatile liquids should be segregated and stored in standard safety containers, preferably underground if the liquid is kept in any large quantity. Windbreakers and tarpaulins should be properly secured, and their surroundings should be checked for possible fire sources. Welding should be supervised and all adjacent combustible material either removed or adequately protected from the flame and flying embers. Stairways and exits must be properly maintained in order to enable quick evacuation of the structure and extinguishment of the fire at any location.

Exercises (443):

Fill in the blanks in the following statements.

1. Usually a building will offer____ ____ ____ while under construction than when completed.
2. One reason buildings burn down before they are completely up is that usually there is no ______ ______ ______ immediately available.
3. It is recommended that construction sites on air bases should have made available to them fire extinguishers in____ ____and be ____ ____throughout the project.
4. A standpipe system should be set up in tall buildings in anticipation of a fire at______ ______where____ ____are present.
5. Heaters and heating equipment should be ______ and ______, located where it will not ignite other material, and must be ____________.
6. If gasoline and other volatile liquids are kept in large quantity, they should be stored ____________; while smaller amounts should be________ and stored in____ ____ ____.
7. Besides being supervised, all welding operations should have adjacent combustible materials either removed or adequately protected from the______and____ ____.
8. Stairways and exits must be properly maintained in order to enable____ ____ of the structure and extinguishment of the fire at____ ____.

444. Point out typical hazards encountered in office buildings and measures taken to eliminate them.

Office Buildings. Office buildings and structures where administrative or clerical duties are carried on are involved in approximately 60 percent of the fires that occur during the night. This factor alone makes office areas hazardous, since nighttime fires can spread further, undiscovered, than fires which occur during the day. The principal hazards in an office involve smoking, matches, and poor housekeeping; however, spontaneous ignition of oily rags and defective electrical wiring also are factors which require the strict attention of fire inspection personnel. Wastebaskets should be made of fireproof material, preferably metal. Ashtrays should not be emptied into waste receptacles, and interior waste receptacles should be emptied each evening into a metal container outside and a safe distance from the building. Oily rags used to polish office furniture should be removed from the building immediately after use, unless they are kept in a self-closing metal container.

Special attention should be given to all large unbroken areas where fire propagation is not impeded. Stairs, elevators, and other escape facilities should be inspected from the standpoint of condition, accessibility, and the possible vertical spread of the fire. From the standpoint of life safety, an alarm system, adequate exits, and panic-exit facilities should be installed and constantly tested and inspected. Particular attention should be paid to the type, quantity, location, size, and locking and closing implements of all doors in the building which are normally used, in addition to all exits for emergency evacuation of the building.

Exercises (444):

1. What are the principal hazards encountered in office buildings?

2. Where should rags used to polish furniture be kept?

3. During an inspection what areas should receive special attention?

4. Normal and emergency exits should be checked for what?

445. Cite hazards encountered in warehouses and general storage areas, and means to eliminate the hazards.

Warehouses. In a warehouse the common hazards of which the fire inspector must be particularly observant are smoking privileges and habits, the careless accumulation of rubbish and combustible materials, faulty use and installation of heating facilities, and electrical devices and their related parts. Actually the individual warehouse fire hazard possibilities are dependent upon the construction of the warehouse, its location, and the type of materials stores. Depending upon these greatly variable combinations, many warehouses will not be permitted to accept certain hazardous materials, such as combustible fibers or materials having spontaneous-ignition characteristics.

General Storage Precautions. Whether materials are stored outside or in protected warehouses, large quantities should be dispersed to discourage fire propagation. At the same time, ample space for extinguishment activity and the firefighting equipment should be allowed. Fire losses are greatly decreased if the various classes of supplies are stored systematically.

Fire extinguishers must be strategically placed and plentiful in all store rooms, and other locations where flammables are present, for the purpose of controlling fire at its outbreak. Instructions must be provided, telling the occupants of the buildings to call the fire department immediately if fire occurs, *then* attempt to quell the blaze with first-aid extinguishers. The only exception is if ample personnel are present to fight the fire and turn in the alarm simultaneously.

Where special precautions are necessary, signs ordering "No Smoking" and giving the recommended procedure in event of fire should be conspicuously placed. Both civilian and military personnel should report without delay any violations of fire regulations to the responsible person in charge.

Engine fuels, lubricants, gasoline, and coal should be stored separately on bases that are without previously installed permanent facilities. Since the flat, circular ends of a drum are its weakest points, gasoline and oil drums should be stacked on end, in small piles. The possibility of ruptured drums causing the spread of fire over a wide area is thus, to a great extent, prevented.

Flammable liquids should be placed on a slope away from danger so that the free liquid will drain off in a safe direction. When storage involves great quantities of liquid fuel, segregate the fuel into group volumes as small as practicable. Earthen dikes should be erected around each group so that, in case of fire, they will form burning limits to contain the burning oil within a single area.

All types of ammunition should be stored in isolated areas in individual piles, separated by enough space to allow passage of vehicles for purposes of fire extinguishment and for removal of exposed ammunition to a safe area during the course of a fire. If possible, ammunition piles should be segregated to prevent an individual pile from exploding another or a series of others and thus causing the complete loss of materials in the area. The distance between piles can be determined by the type of ammunition and its characteristic reaction upon detonation.

Exercises (445):

1. What are the common hazards an inspector must be watchful for?

2. What are individual warehouse fire hazards dependent upon?

3. How may fire propagation be discouraged?

4. How may fire losses be greatly decreased?

5. Who should report fire regulation violations? When and to whom?

6. What are the weakest points of POL drums?

4-3. Special Hazard Areas

We can group structures generally according to their fire-hazard possibilities by noting their construction, contents, and external exposure. But individual structures on every airbase offer fire hazards technically and specifically different from all other buildings. Two buildings of the same design and constructed of identical material may be located in different positions; if so, we have two different problems of exposure and general environmental fire hazards. The varying habits of the occupants also create conditions which demand digression from any standard fire inspection and prevention procedure. Therefore, when inspecting in a strange environment, the fire inspector, armed with a general knowledge of procedures acquired through theoretical or practical experience, must be thorough, alert, and firm in his decisions. It is not possible, then, to state precisely the specific conditions which must be corrected or eliminated. The fire inspector must use his specialized knowledge and his own initiative.

Only the most modern buildings—those fire-resistive constructions of brick, stone, concrete, and steel which are equipped with metal doors, window frames, and wire-reinforced glass panes—approach ideal structural conditions; even then, they are considered quite safe only where the combustible material in a given area is of negligible quantity. However, unless all buildings are structurally fire resistive, there can be no assurance against devastating major fires or even a decrease in the size of fire protection organizations. Since few cities, communities, industrial areas, or military bases even approach this firesafe condition, the need for fire protection is still strong, as it no doubt will continue to be.

446. Indicate whether given statements concerning special hazards encountered in hospitals and theaters are correct. If a statement is invalid, correct it.

Hospitals. Airbase hospitals are a major consideration, primarily because of the patients. The most important hazards and processes responsible for fires in hospitals, listed in order of frequency, are electrical defects, defective chimneys and flues, sparks on roofs, incendiary causes, smoking and matches, ignition of grease and flammable liquids on stoves, and spontaneous ignition. Approximately 39 percent of the loss of life in hospital fires is attributed to insufficient exits. This condition, coupled with the fact that many patients are bedfast and unable to evacuate the building unassisted, offers a series of major problems which the fire inspector must closely consider in his responsible position.

Theaters. Base theaters create a life safety problem which is almost comparable to that of hospitals. Any large gathering of people indoors is subject to mass panic. Panic frequently occurs without good reason, especially if exits are faulty or inadequate. Almost half of the fires that occur in theaters originate in the projection booth from defective, overheated machines and sparks from any number of sources. The projection booth should be built on the outside of the theater wall so that fire originating in the projection booth is reasonably confined outside the theater seating area. If the projection booth is inside, it should be constructed of fire-resistive material and vented to the outside.

When scenery is present, it should be treated with a substance that will make it fire resistant. Scenery, often consisting of cotton duck and light wooden frames, usually is stored close together and offers great fire propagation possibilities. In the stage area, the fire inspector should closely observe dressing rooms, heating devices, sound equipment, repair rooms, paint shops, smoke vents, and temporary wiring; and he should make certain that careless smoking habits of those who frequent the stage are reduced to a minimum. There should be no combustible material present in the theater auditorium except chairs and carpets. A low "firewall" to the level of the stage, and of solid and permanent construction, should stand between the stage area and auditorium; the stage itself should be equipped with a sliding asbestos or rigid metal curtain. When the curtain is dropped, it meets this low firewall, and the stage area is separated from the auditorium.

Where possible, a sprinkler system should be installed throughout the theater, with the exception of the auditorium area. All doors in a theater must open outward and be equipped with panic bars or some similar arrangement to allow opening of the doors with the application of outward pressure. There must be a sufficient number of exits of a proper width, plainly marked and unlocked, to guarantee the safety of the people in attendance.

Motion picture and camera film are common on an airbase. Previously, films consisted almost wholly of cellulose with a nitrate base; these set up a very hazardous condition. The nitrate burned easily, with great speed, and was capable of an explosive reaction when confined.

The nitrate-base film is gradually being replaced with an acetate-base film which is comparatively fire-resistant and which requires only moderate fire safety measures. When the use of nitrate-base films is required for one reason or another, the film should be stored in a fire-proof, explosion-proof vault or safe, away from all sources and supporters of ignition, including steampipes and flammable material. When there is any doubt at all about the composition of the film, a small sample of it may be removed to a safe area and ignited, as a test. Flammable films should be stored in small quantities.

Exercises (446):

If one of the following statements is correct, mark it True; if it is False, correct it.

___1. Smoking and matches are the most important hazard and are responsible for most of the fires in hospitals.

___2. Approximately 39 percent of the loss of life in hospitals is attributed to faulty sprinkler systems.

___3. Almost half the fires that occur in theaters originate in the projection booth.

___4. To reasonably confine a fire originating in the projection booth outside the theater seating area, the projection booth should be built on the outside of the theater wall.

___5. Where the projection booth is inside the theater, it should be constructed of fire-resistive material and be vented to the outside.

___6. The scenery in a theater, whether in storage or in use, should be treated with a fire-resistive substance.

___7. A solid, permanent, low firewall (to the level of the stage) should stand between the stage and the auditorium, and the stage itself should be equipped with a sliding asbestos or rigid metal curtain which, when dropped, will meet the firewall.

___8. A sprinkler system should be installed, where possible, throughout the theater to include the auditorium area.

___9. The doors in a theater must be so designed that they will open with the application of outward pressure.

___10. The nitrate-base film in use is comparatively fire resistive and requires only moderate fire safety measures.

447. Identify special hazards encountered in fuel servicing and measures taken to minimize the hazards.

Fuel Servicing. Aircraft hangars normally are potential fire hazards because of the flammable vapors caused by fuel, "dope" used on wings and control surfaces, lacquer, paint, and oil. The ventilation system must be capable of carrying off these vapors before they accumulate sufficiently to ignite. Spark and flame-producing actions and devices, such as blowtorches, engines and their exhausts, heaters, short circuits, smoking, and the use of matches should be completely eliminated in hangar areas.

When aircraft are brought (even for a brief time) into a repair shop or hangar for repairs or for storage after having been serviced with fuel, great care should be taken to prevent the overflow of fuel tanks, the expansion of the fuel being caused by temperature changes. Aircraft must not be refueled or drained of fuel while they are parked inside of buildings.

When they are being refueled, aircraft should be removed from each other as far as prescribed regulations dictate. In case of fire, this distance lessens the danger of the fire's spreading from the burning aircraft to the others.

Fuel trucks, loaded or empty, must not enter or be stored in hangars. They may be parked within 100 feet of hangars, paint and dope shops, fuel storage systems, or other critical installations only long enough to load or unload their cargo. Fuel trucks should never be parked in concentrated groups, but rather as far apart as is practicable.

Drums and other receptacles containing gasoline, oil, dope, paints or varnishes must not be kept in hangars or other buildings where aircraft or flammable aircraft parts are stored. Small quantities of certain of these materials may be kept available for immediate use if safety containers are used and additional necessary fire precautions are taken. Flammable liquids, esecially gasoline, should not be used as a cleaning solvent, nor should they be discharged in sewage or drainage systems. Aircraft and other equipment may be cleaned with flammable materials *only* under competent supervision, as prescribed by current technical orders, with ample fire extinguishers at hand.

When weather conditions, temperatures, or dust make it advisable, aircraft may be serviced with oil while in the hangars, but care must be taken not to spill oil on the floors or to allow it to accumulate in drop pans or other containers. As previously stated and sufficiently important to repeat, certain gases or vapors, like those of gasoline, normally settle to the floor; others, such as hydrogen, rise to the ceiling. Such characteristics of liquids or gases should be noted by those dealing with them, and appropriate precautions taken. A gas or vapor explosion may occur just as easily from the action of a tool spark, a spark from the nail of a shoe, or a static electrical discharge, as from a match or a blowtorch. Though the extensive use of nonferrous metals in aircraft construction reduces tool sparks to a minimum, such metals are not immune to static charges. Although aircraft casings are purposely made with electric-current-carrying characteristics, this protective feature is not entirely dependable when an aircraft is resting on a dry concrete runway or floor. An aircraft parked in a hangar can be electrically charged by the friction of air over its surfaces. Merely the touch of a hand may force discharge of an almost invisible spark which will cause an explosion if the surrounding atmosphere is vapor-laden with the proper proportions of oxygen. This condition is more likely to exist during cold, dry weather than during warm days. Therefore each aircraft should be grounded, preferably to a specially installed ground pole or a water pipe. The structural members of a building are not necessarily grounded, except those on which water pipes are mounted.

When you are working where fuel vapors or other combustible vapors might be encountered, use vapor-proof and explosion-proof lamp assemblies exclusively. No portable-type lamp assembly should be used in any maintenance shelter without a proper guard or wire shield to protect it from breaking. Special caution should be taken to prevent the accidental making or breaking of the electrical connections. In all buildings where fuel piping and equipment are used, or where flammable or volatile liquids must be used, handled, or stored in other than their original containers, adequate natural or forced ventilation must be provided. Fire extinguishers, preferably the carbon dioxide type, should be available when aircraft engines are started.

Exercises (447):

1. Why are fuel servicing operations hazardous?

2. The use of what devices should be eliminated in hangar areas?

3. What may cause fuel tanks/cells to overflow when aircraft are parked in a hangar?

4. Why should aircraft be moved outside before they are serviced with fuel?

5. Fuel trucks should be parked no closer than how many feet to a hangar?

6. How are tool sparks on aircraft kept at a minimum?

7. Why must aircraft be grounded when parked in a hangar?

8. What type of lamp assemblies must be used when working in combustible vapor areas?

9. What must be provided in areas where volatile or flammable liquids are used or handled?

448. Complete statements concerning special hazards encountered in woodworking, paint and spraying shops, and machine shops.

Woodworking Shops. Woodworking is probably the most common construction and manufacturing activity on the average airbase. In a woodworking area the fire inspector must be extremely cautious, because wood is very combustible, especially under shop conditions. Wood waste materials—sawdust, shavings, and even the lumber itself—present a fire hazard in view of the danger of dust explosions or ignition by steampipes. The construction protection and the general housekeeping of a shop are the important factors of fire prevention. The accumulation of sawdust, usually mixed with lubricating oil, on machinery surfaces becomes a serious hazard when overheating occurs. Paints, varnishes, rags containing flammable liquids, glue pots requiring heat, and many other possible hazards make it necessary for the fire inspector to be exceptionally alert in detecting fire possibilities.

Painting and Spraying Shop. When making inspections in any location where paint and lacquer spraying is performed, whether it involves vehicles, aircraft, or simply structural interior decorating, you may always be fairly certain that flammable solvents, ignitable at low temperatures, are present in the atmosphere. Ventilation is the best insurance against vapor ignition, and each compartment or spray booth should be equipped with an individual exhaust duct, including a spark-proof fan. The use of heat for drying purposes increases the fire hazard in paint-spray areas and increases the necessity for caution. Electrical hazards are the greatest source of fire danger in a paint-spray area. Spontaneous ignition and careless operation and maintenance habits are also high on the list of fire hazards.

Machine Shops. Machine shops include those metalworking plants which perform the processes of turning, planning, milling, drilling, and grinding metal parts. The specific fire hazards which may be found in a machine shop involve furnaces and forges, annealing ovens, hardening ovens, fuel-oil systems, fuel, gas, quenching oil, oil tempering, methods of heating, and possibilities of overheating. All of the preceding hazards should be thoroughly inspected for the fire safety elements of installation, condition, and general environmental factors. The fire hazards of sparks from welding and cutting processes must be reduced to a minimum. Spark sources from all heat-creating devices, including forges, furnaces, electrical installations, static, and machinery, should be checked and traced to their eventual destination. Special care should be taken to assure against live sparks falling on combustible materials in the vicinity of machine shops.

Exercises (448):

Fill in the blanks in the following statements.

1. Wood waste materials—sawdust, shavings, and even the lumber itself—present a fire hazard in view of the danger of ________ ________ or ________ ________ ________.
2. The important factors of fire prevention in woodworking shops are the ________ ________ and ________ ________ of the shop.
3. When sawdust is allowed to collect on machinery and mix with lubricating oil there, it becomes a serious fire hazard as a result of ________.
4. You may always be fairly certain that ________ ________ are present in the atmosphere when you make an inspection of any location where paint and lacquer spraying is performed.
5. The best insurance against vapor ignition in a painting and spraying shop is ________.
6. There is an increased fire hazard necessitating an increase in caution when ________ is used for ________ ________ in paint-spraying areas.
7. The greatest source of fire danger in paint-spray areas is ________ ________.
8. All hazards associated with machine shops should be thoroughly inspected for the fire safety elements of ________, ________, and ________ ________ ________.
9. Special care should be taken in machine shops to assure against ________ ________ falling on combustible materials.

4-4. Miscellaneous Hazards

The following hazards were not as easy to categorize as those that we have just discussed, so we decided to lump them into this grouping because they were too important to leave out. Actually the items in this whole section cannot be considered as a complete list of hazards that a competent fire inspector will notice and correct and control. This section just covers some of the hazards that can be found almost everywhere.

449. Point out hazards encountered with given miscellaneous hazards, and name the measures taken to minimize or to eliminate those hazards.

Sparks. Live sparks from chimneys, refuse burners, stacks, and other similar sources must be given priority consideration. Spark-arresting screens can be installed over the openings, but their efficiency is limited. A large mesh screen will let many sparks through and a small mesh screen will soon become carbon-congested and impede the passage of smoke. The best procedure is to obtain medium mesh screens of heat-resisting alloy metal. Such screens will require periodic cleaning; but they will allow only those sparks having a limited "glow life" to escape, retaining those large and more dangerous embers in the stack. During periods of low humidity and high wind velocity, special precautions must be taken in those areas where fire risk is not negligible.

Mechanical Devices. Engines of any type, or other machines in which friction is created, are possible sources of fire. A common example of this is a fire caused by overheated bearings. Wherever there are engines, there should be frequent elimination of lint and dust from the immediate surroundings of the moving mechanical device, and all excessive flammable lubricants should be removed promptly.

Grinding wheels and other spark-producing equipment are a frequent cause of fires and should not be permitted in areas which might contain highly flammable gas or vapors. Neither should flammable material or any type be left in an area where sparks may fall upon them.

Blower systems include all duct installations, whether used for ventilation, air conditioning, or dust and vapor elimination. Most dust, including that of some metals, constitutes an explosion hazard where a spark is possible. These sparks may be struck by fan motors, overheated fan bearings, or the movement of the fan against surrounding metal. Blower fans or their metal housings should consist of nonferrous metal. The ducts must be of metal and free from contact with wood or other flammable material. They must also contain ports which will permit frequent cleaning and compartment dampers which will isolate the fire to a single section if prevention fails.

Acids and Other Chemicals. The strong acids, including nitric, sulfuric, and hydrochloric, are not in themselves flammable or supporters of combustion. The chief hazard of these acids lies in the possibility of their leaking or spilling from their containers. Fire or explosion is possible if they are allowed to come in contact with other acids. Heat may cause nitric and hydrochloric acids to expand and burst their containers. Nitric acid is capable of igniting some flammable materials. Strong acids should be stored in a cool compartment unexposed to the hot sun and free from all flammable materials.

Sulfur. Sulfur melts and flows while burning. It should be stored away from heat and other chemicals. Handling of sulphur creates sulfur dust, which is subject to explosions. Phosphorous, which ignites spontaneously upon contact with air, is poisonous and is a serious fire and personnel hazard. It should be kept under water in a tin container in complete isolation from other chemicals. Care should be taken to prevent mechanical injury to the container.

Chlorine. Chlorine is a heavy, greenish, poisonous gas given off by many manufacturing processes. It is not flammable itself but may cause fire or explosions when in contact with ammonia, turpentine, or finely powdered metals. Ventilation is of paramount importance where this gas is generated.

Chlorates, nitrates, and peroxides. Chlorates, nitrates, and peroxides are all hazards because they emit large quantities of oxygen when heated. Many of their constituents may be detonated or exploded when in contact with such materials as starch, sugar, dust, organic matter, and sulfur compounds. Many peroxides may ignite nearby flammables when exposed to moisture.

Coal-Tar Derivatives. Coal-tar derivatives in both crude and refined forms are being used quite extensively. Dyes, medicines, and explosives are manufactured from these coal-tar products. Since coal-tar derivatives are hazardous, many fires and explosions have been caused by carelessness. The preparation, handling, and storage of these materials require the same precautionary methods as do gasoline, benzine, and similar flammable liquids.

Effects of the Sun. The sun frequently is responsible for fires, though it is usually assisted by some manmade implement. A fire inspector must be especially observant of these implements, because under most conditions, they are extremely difficult to detect as fire hazards. For example, forest fires have been known to start from discarded bottles of other fragments of glass left by careless campers. The sun's rays, shining through a piece of glass which may be so ideally curved and placed as to act as a lens, are concentrated so as to ignite a piece of paper. Similiarly, curtains can be ignited by a windowpane containing a bubble or some other irregularity. Fire may also result from the sun's shining through such things as laboratory flasks, fish bowls, water bottles, and concave mirrors (which reflect heat). The sun also contributes to spontaneous heating, thus aiding ignition. (During warm seasons when buildings are closed for the weekend, sprinkler heads located beneath skylights and in attic spaces may be discharged, often resulting in considerable water damage.)

The possibility that the sun will start a fire is somewhat remote. However, when we consider the numerous conditions which may create these so-called freak fires and the fact that any one of them may completely destroy a building, or even many buildings, we realize that these possibilities deserve careful consideration.

Exercises (449):

1. What consideration must be given to sparks from any source?

2. What is the best procedure to use when installing spark-arresting screens?

3. When must special precautions be taken in areas where the danger from sparks is high?

4. What is a common cause of fire in machines?

5. How may the chance of fire around engines be lessened?

6. What type of hazard does dust present if a chance of a spark is present?

7. What is the chief hazard of acids and other chemicals?

8. When is fire or explosion possible with acids?

9. What poisonous gas is given off by many manufacturing processes?

10. Why are chlorates, nitrates, and peroxides all hazards?

11. How may a windowpane start a fire?

CHAPTER 5

Fire Prevention Training and Public Relations

THE BASIC GOAL of any fire protection program is the prevention of fire. To achieve this goal, it is necessary to reach the basic cause of fires - PEOPLE - with an agressive, year-round fire prevention educational program. This program must be directed toward every individual—military, dependent, and civilian. It must be a continuous program covering the fire-prevention aspects of every area and field of endeavor. This is a tremendous task requiring the maximum in effort, imagination, and cooperation. The first section of this chapter will provide information which will assist you in the various methods of developing such a comprehensive fire prevention education program.

As a part of a good fire prevention program, your department should maintain a close relationship with the surrounding civilian communities. One of the ways this is done is through a mutual aid agreement, which we will discuss in the latter part of this chapter.

5-1. Fire Prevention Training

The value of your training program will depend upon the amount of work you put into it—little work, little value. Let's take a closer look at the makeup of an effective fire prevention training program.

450. Given a series of statements concerning fire prevention training, complete the statements by filling in the correct word(s) and/or phrase(s).

As established in AFR 92-1, the prevention of fire is a basic command function to which commanders at all levels must give their personal attention. Every commander, regardless of the size or function of their command, shares this responsibility and must assure an effective program within their area. The key to the success of this program is the training of personnel within each functional area.

The value of an educational program lies in the idea that well-informed people, properly educated and motivated, will be willing to go along with a directive or a system of controls that they can easily understand and relate to.

Fire prevention educational programs, if properly prepared and presented, will do the following:

- Foster support of fire prevention.
- Develop good habits toward the concept of fire prevention.
- Enable personnel to initiate proper procedures in the event of fire.
- Aid in the success of the overall fire protection program.

Exercises (450):

Fill in the blanks in the following statements.

1. The prevention of fire is a basic command function to which commanders at __________ __________ must give their personal attention.
2. The key to the success of the fire prevention program is the __________ __________ within each __________ __________.
3. Well-informed people, properly educated and motivated, will be more willing to go along with a directive or system of controls that they can __________ __________ and __________.
4. Fire prevention educational programs will foster support of fire prevention and aid in the success of the overall fire protection program if they are __________ __________ and __________.

451. Indicate whether given statements concerning fire prevention program development and types of programs are correct. If a statement is invalid, correct it.

Program Development. In developing a fire prevention educational program, a specific set of goals must be determined first. We must ask ourselves the following questions:

1. To whom is the program designed to help?
2. What are their specific needs in relation to fire prevention?
3. What am I trying to accomplish in the presentation of this program?
4. What resources must I call upon to accomplish this program?
5. How, when, and where will I present this program?

Consideration, thoughtful planning, and imaginative effort must be applied in order to answer each of the aforementioned questions in a manner which ensures the success of our programs. The development of a fire prevention educational program is not easy. Only through sound planning will our efforts be rewarded.

Types of Programs. There are two types of educational programs normally categorized as general and specific.

General programs are those designed to present the fundamentals of fire prevention to the general base populace.

Specific programs, like their name implies, are directed toward specific hazardous areas—areas where the inherent hazard is part of the operation and, therefore, the personnel working in these areas need specialized training.

Exercises (451):

If one of the following statements is correct, mark it True; if it is False, correct it.

___1. The first thing to do in developing a fire prevention educational program is determine a specific set of goals.

___2. After you have determined to whom the program is designed to help, you should determine their specific needs in relation to fire prevention.

___3. The two types of fire prevention educational programs are normally categorized as general and specific.

___4. Specific programs are those which are designed to present the fundamentals of fire prevention to the base populace as a whole, while general programs are directed toward a given hazardous area and operation and the personnel working in those areas.

452. Given a list of statements concerning youth-centered fire prevention programs, match the statement to the type of program it is most closely associated with.

Scout Program. This is a rewarding year-round program. While requiring more effort than some of the other programs outlined here, the results can be manifold. The most desirable beginning to this program is for the fire department to sponsor a scout unit. This is a well-rounded program in which you will be doing a service to the boys and girls as well as to the community. Some of the programs related to fire prevention in which scouts participate include:

- Merit badge awards in "Firemanship" for boys and "Home, Health and Safety" for girls.
- Handing out literature during various fire prevention campaigns.
- Assisting in base beautification programs.
- Establishing fire-safe camping demonstrations.
- Performing specific duty such as fire hydrant clean-up and painting.
- Participating in fire prevention campaign parades with a float and/or marching unit.

If sponsorship of a troop is not feasible, encourage scouts' visits to the fire station; offer the station as a meeting place; assist them in achieving their merit badges; invite their participation in your programs; and in any other way, encourage and support the scout program. The benefits you gain in return far exceed the effort expended.

School Program. Like the scout program, the school program will require some effort, but the return will be far greater. Not only can the children learn fire-safe practices, but they will influence the behavior patterns of their parents. While most fire departments stress evacuation drills and fire inspections of schools, many other subjects can be developed. A partial listing of some other fire prevention activities for school includes:

- Assure that special procedures are established for evacuation of handicapped children.
- Present a word on fire prevention at each school assembly.
- Integrate fire prevention into existing courses of instruction, such as science (chemistry of fire, fire extinguishers, and agents), English (essays), civics (organization and responsibilities of a fire department), art (posters), etc.
- Conduct school bus fire drills, to include actual use of exits, including emergency exit; location and proper use of fire extinguisher; location of fire axe and first aid kit; marching away from the bus to a safe distance; posting warning flags, etc.
- Conduct a regular class on "Dos and Don'ts" during fire drills.
- Participate in poster and slogan contests.

- Provide children with home inspection forms and have them inspect their own homes. Be sure to have the parent sign the form before the child returns it to school.
- Conduct waste paper drives.
- Devote a part of some PTA meetings to school fire prevention talks, movies, demonstrations, etc.

Sparky and Junior Fire Marshal Programs. These two programs are directly related to the school program in that they deal with children and are often conducted at the school. They may, however, be conducted as separate programs where schools are not located at or near the installation.

Sparky Fire Department. This outstanding program, established on a nationwide basis by the National Fire Protection Association, is directed toward kindergarten and primary graders. An abundance of promotional and educational material is available at a nominal fee. The children receive a badge, membership cards, and inspector's handbook. In addition, puzzles, bookcovers, coloring books, home inspection blanks, and other materials are available. Complete details are available from the NFPA.

Junior Fire Marshal Program. This excellent program for older children has been developed over the years and has had excellent results. One such program has in each school room a chief inspector, each floor a lieutenant, each building or wing a captain, with a chief and assistant chief for all buildings. Home inspections are conducted by all students, and training may be received either at the school or fire department.

Babysitter Programs. This subject used to be restricted to various girl's clubs, but since many boys and older persons are now employed as babysitters, it should be a program for all, conducted at the fire department, theatre, school auditorium, or other suitable place. One approach is to publicize the program widely, with the recommendation to parents that no sitter be hired unless she/he has completed the course. Parents should be encouraged to attend so that they can meet some of the trainees and see the program in progress. (Many parents may become interested in attending themselves!) Refresher training should also be established to maintain sitter proficiency. The course should be designed and conducted with the assistance of other interested agencies, especially the hospital. The NFPA has some interesting pamphlets and other material available on the subject. Course content should include the following:

- What should the parent expect of the sitter?
- What should the sitter expect of the parent?
- General first aid.
- Child care, feeding, bathing, etc.
- How to prevent fires (matches, stoves, etc.).
- How to report a fire.
- What to do in case of fire.
- What to do in case of other emergency.
- Printed sitter's form, including: general instructions; blanks for specific instructions from parents; blanks for telephone numbers of fire department, police, hospital, and/or doctor, place to reach parents while away; neighbor to call in event of emergency.
- Other information peculiar to your specific area.

Exercises (452):

1. Match each of the following statements in column B with the type of program listed in column A that it is most closely associated with. Each statement may be used only once, and some statements are not used at all.

Column A	*Column B*
______1. Scout program.	a. This program is directed toward kindergarten and primary graders.
______2. School program.	b. A part of some PTA meetings may be directed toward fire prevention as a result of this program.
______3. Sparky Fire Department.	c. As a part of this program, girls may receive a "Home, Health and Safety" merit badge.
______4. Junior Fire Marshal Program.	d. This program should be developed for the young and old; girls and boys, as a part of the training for the work they do and should include some refresher training.
______5. Babysitter program.	e. Establishing fire-safe camping demonstrations is one of the many activities that may be included as a part of this program.
	f. In this program, older children are given titles much like those used in civilian fire departments and training is given at either the fire department or in the school.

g. This program is directed toward the base populace as a whole, with a specific subject in mind.
h. Individuals are often encouraged to participate in poster and slogan contest as a part of this program.

453. Complete statements concerning community relations in fire prevention.

Community Cooperation. An important part of base community relations is the cooperation of the base fire department in the community fire prevention program. This is especially true when large numbers of base personnel are living off base. It is important for the community to know that the base is interested in their welfare, while at the same time your program and participation are reaching greater numbers of base personnel. Most community fire departments will welcome your assistance in planning and presenting lectures, films, and demonstrations. Your presence as a speaker or assistant, in proper uniform, will prove to the community that cooperation does exist, and this will be reflected by their attitude toward the installation.

Service, Fraternal, and Social Clubs. A program of lectures, films, and demonstrations should be delivered to all such clubs, including wives' clubs and auxiliaries. Since each type of club has different objectives, each program should be individually designed or adapted to the specific audience. One idea is to develop one general program for men and another for ladies, and then merely adapt the appropriate one to the group. Once interest has been developed among the membership of these clubs, the next step is to encourage their sponsorship and/or participation in the other fire prevention programs conducted throughout the year. This is an important area for development, since club members' support and cooperation will greatly enhance your year-round program.

Exercises (453):
Fill in the blanks in the following statements.

1. The cooperation of the base fire department in the community fire prevention program is an important part of __________ __________ __________, especially when large numbers of base personnel are living __________ __________.
2. Your assistance in __________ and __________ lectures, films, and demonstrations will be welcomed by most community fire departments.
3. The community will know that there is cooperation between them and the base fire department by your presence as a __________ or __________, when in __________ __________.
4. Fire prevention programs for presentation to service, fraternal, and/or social clubs should be individually __________ or __________ to the __________ __________.
5. Once interest in fire prevention has been developed among the membership of various clubs, the next step is to encourage their __________ and/or __________ in the other fire prevention programs conducted throughout the year.

454. Indicate whether given statements concerning fire prevention training requirements are correct. If a statement is invalid, correct it.

Personnel Training. The objective of this training is to develop good habits in fire prevention and to enable personnel to initiate simple procedures in the event of fire. It must be given on a recurrent basis to all personnel. General programs should emphasize basic fire origin, hazard recognition and elimination, seasonal fire hazards, how to report a fire, and what steps to take in the event of a fire. Specific programs should be tailored to the hazards and risks inherent to the local activity of the audience. The following items are minimum requirements established in AFR 92-1.

Newly assigned personnel. Military and civilian personnel, including military dependents, must receive an initial group orientation. Usually this is a general progam with additional emphasis on local fire regulations and procedures. It is essential that these newly assigned personnel understand where they fit into the base fire protection program and what their responsibilities are.

Indoctrination program for nonprofessional firefighters. This is a program to provide training for selected personnel who have specific responsibilities in the event of fire, such as aircrew members, school teachers, charge of quarters, sentries, auxiliary firefighters, etc. Each program must be directed toward those actions required of each individual group. It is imperative that these people be trained to a level of efficiency so as to provide safe evacuation and first aid firefighting. They must also be able to maintain control of a situation until the arrival of the fire department.

Specialized training for selected functional areas. Certain functional areas have severe inherent hazards because of the very operations involved. Among these are liquid oxygen plants, POL storage and dispensing areas, flight-line and aircraft maintenance shops, and similar shops and/or special handling areas. Special programs, each tailored to the specific hazards of the area involved, must be presented regularly to assure the awareness of all personnel to the fire prevention and safety procedures in their respective areas.

Refresher training. The secret to the success of any training program is repetition. Each individual must receive additional training at regular intervals, lest his proficiency become ineffectual. Mission requirements and the accompanying support facilities are constantly being changed and/or updated. In addition the constant turnover of personnel requires that this training cover all new personnel. Therefore the need for refresher training programs can readily be seen. Generally such training can be accomplished in connection with group scheduled meetings, such as unit staff meetings, General Military Training, wives' clubs, PTA, etc. When this is not feasible, separate training periods must be established.

Contractors, vendors, concessionaires, and others. Indiscriminate practice by commercial organizations and individuals continue to contribute heavily to annual fire loss of the Air Force. All personnel having recurring business on the installation must, therefore, receive an orientation in Air Force and local fire prevention practices. This is especially true overseas and in other areas in which our national standards are not accepted or practiced. This indoctrination should be accomplished prior to granting final approval to commence operations, and it should include:

- Base fire regulation.
- Individual's responsibilities in fire prevention.
- Fire reporting procedures.
- Fire prevention.
- Environmental control (housekeeping, etc.).
- Control of open flame devices.
- Control and disposal of smoking materials.
- Use of flammable liquids.
- Storage requirements.
- Hazardous area locations.

Military family housing. Family sponsors are responsible for fire prevention in their quarters. They insure that dependents are familiar with the fire prevention instruction in the family housing brochure, know how to report fires, and know how to evacuate their quarters. Occupants receive a fire prevention orientation within 30 days of occupancy.

Exercises (454):

If one of the following statements is correct, mark it True; if it is False, correct it.

____1. The objective of fire prevention training is to develop good habits in fire prevention and enable personnel to initiate simple procedures in the event of fire.

____2. All military and civilian personnel, including military dependents, must receiv an individual orientation which is usually a general program with additional emphasis on local fire regulations and procedures.

____3. It is essential that newly assigned personnel understand where they fit into the base fire protection program and what the commander's responsibilities are.

____4. Nonprofessional firefighting personnel who have specific responsibilities in the event of fire must be given training to a level of efficiency to provide safe control of a situation until the fire department arrives.

____5. Personnel assigned to certain functional areas such as POL areas and aircraft maintenance shops are to receive general training tailored to the general hazards of the area involved.

____6. Each individual must receive refresher training at regular intervals to maintain their proficiency in fire prevention.

____7. All personnel doing business on an Air Force base must receive an orientation in Air Force and local fire prevention practices.

____8. The indoctrination of contractors, vendors, and concessionaires should be accomplished after the completion of arrangements in granting final approval to commence operations on the installation.

____9. Husbands are responsible for fire prevention in their military family housing; the occupants of this housing are to receive a fire prevention orientation within 14 days of occupancy.

455. Complete statements concerning the promotion of fire prevention programs.

Use of News Media. It is essential that all of the aforementioned programs be given the widest possible publicity through the news media. A close liaison should be maintained with the Office of Information from which valuable assistance may be gained. The following is a list of news media which should be used to the greatest advantage:

- Daily Bulletin.
- Base newspaper.
- Armed Forces Radio and Television Service.
- Base theatre.
- Commander's Call.
- Bulletin boards.
- Staff meetings.
- Commercial (community) versions of above.

Advertising. The failure of a fire prevention program can be caused by the fact that the base fire department was given or that it assumed total responsibility for the task. This should not be the case. Specifically, the base fire chief, through the base fire marshal, manages the program, and each person on the base exercises the program. Only after this is understood can the cliche be accepted that "Fire prevention is everybody's business."

Fire prevention technicians not only must know their job well, they must also be able to sell the fire prevention program. This brings us to the subject of salesmanship advertising. All advertising, regardless of the product or service involved, falls into one of three categories. Understanding these categories will assist you in developing material and selecting the media to use.

Comparative. This type of advertising involves the relationship between two or more items, i.e., "Our product is better than our competitors because. . ." In fire prevention, comparative advertising is used when the consequences of fire are advertised. This is not the most desirable type of advertising because it gives the reader a choice; the consequences of fire may be worth the risk to some and not to others.

Imperative. This type of advertising is just what it implies: the "Buy Bonds" theme is an example. In fire prevention, written regulatory guidance and recommendations during inspections are forms of imperative advertising. We must point out here that a document containing a series of "don'ts" is less likely to succeed than a document containing "dos." Specifically, people form habits by doing things. They are more apt to develop good fire prevention habits by practicing what should be done than by avoiding what shouldn't be done.

Nominative. Nominative advertising is best exemplified by the automobile company which advertises its product with a picture of a cougar and the name of the car. In fire prevention "Sparky" the dog is nominative advertising. Base fire departments can develop rubber stamps with a symbol for use in base-wide correspondence, bulletins, and newspapers. The object is for the reader to immediately associate the symbol with fire prevention. This type of advertising is good for evaluating the effectiveness of the fire prevention publicity program.

Exercises (455):

Fill in the blanks in the following statements.

1. It is essential that your fire prevention program be given the widest possible publicity through the use of __________ __________ __________.
2. Much valuable assistance in the promotion of your fire prevention program may be gained from the __________ __________ __________ if a close liasion is maintained with them.
3. The base __________ __________, through the base __________ __________, manages the fire prevention program and __________ __________ exercises the program.
4. An understanding of the three categories of advertising will assist you in __________ __________ and __________ __________ __________ to use in your fire prevention program.
5. When you elect to advertise a fire prevention program and the consequences of fire are used in that advertising, then you have used the __________ type of advertising.
6. The fact that people are more apt to develop good fire prevention habits by practicing what should be done than by

avoiding what shouldn't be done is a basis for initiating an__________type of advertising campaign stressing "DOs."

7. The object of nominative advertising is for the reader to associate a__________with a product; such as "Sparky" with fire protection.
8. Of the three types of advertising discussed, the__________type is considered good for evaluating the effectiveness of the fire prevention publicity program.

456. Cite programs used in promoting fire prevention.

Competitive Programs. To maintain the year-round exposure of fire prevention practices to all personnel, we must establish numerous and varied programs. Every group and organization must be included in the planning of these programs so as to assure maximum coverage. Many of these programs should be initiated and monitored by the fire department, with the actual program conducted by organizational personnel. The basic concept here is to increase the impact of the overall fire prevention program through the participation of all personnel. The following programs show the scope of such undertakings.

Functional activities. Separate programs should be developed by each functional activity (field maintenance, motor vehicle maintenance, base operations, POL, munitions, supply, LOX plant, civil engineering, tactical organizations, tenants, etc.). These programs should consist of lectures, demonstrations, films, posters, handouts, etc., tailored to the specific activity and stressing those hazards within each work area. Certain high hazard areas require more emphasis and/or more frequent training; however, all functional areas should be included in the recurring program.

Local base competition. This program usually endorsed by the Commander's Fire Protection Council, recognizes the organization demonstrating the most fire prevention consciousness over a given period (generally a calendar quarter). The winner is selected on a basis of a point system established against a list of accomplishments. The entire list of organizational standings should be published once each quarter, with the winner receiving a trophy and suitable recognition. The trophy/plaque may be awarded for permanent retention or may be passed on to the subsequent winner. Accomplishments worth merit include:

- Attendance at approval fire prevention training classes.
- Work orders completed to correct existing fire hazards which were initiated without outside reference.
- Correctable fire hazards existing outside an area of responsibility submitted in writing to the fire department.
- Suggestions submitted on AF Form 1000 resulting in an improvement directly concerning fire prevention/hazards.
- Deduction of points for each correctable fire hazard noted on inspection by a fire prevention technician.

Seasonal campaigns. Additional effort should be expended during certain seasons to cover those hazards peculiar to that time of year. Special posters, spot announcements, handout pamphlets, etc., for each of these periods are available through various sources. All news media should be used so as to assure maximum coverage, as all personnel are affected during the following seasons:

- Spring and fall (cleanup campaigns).
- Cold weather (heating appliances, electric pads, blankets, etc.).
- Hot weather (air conditioning, fans, etc.).
- Summer (camp fires, barbeques, trash burning, etc.).
- Christmas (decorations, trees, wrapping materials, etc.).

Monthly fire safety campaign. This is a direct attack each month against a different type of fire hazard. The attack is done through letters to supervisors, through posters, announcements in daily bulletins, articles in the base newspaper, and spot announcements on Armed Forces radio and television networks, and/or cooperating commercial news media. Generally the subject for each month is either a particular problem area existing at the time or one of the following leading causes of fire.

- Smoking materials, matches, and their disposal.
- Heating and cooking appliances.
- Electrical appliances.
- Flammable liquids and appliances.
- Electrical wiring.
- Internal combustion engines.
- Ignition of greases, tar, wax, etc.
- Open flames, ashes, etc.
- Spontaneous ignition.
- Sparks and flying brands.
- Environmental control (housekeeping).
- Lightning and static electricity.

National Fire Prevention Week. This program is separate because of emphasis placed on it as one of the special weeks declared by Presidential proclamation. It is during this week that special emphasis is placed on fire prevention to everyone on the installation and in nearby communities. All of the programs explained above should be escalated, with maximum effort expended on making the public aware of fire dangers. An excellent source of ideas for additional promotional programs for the week is the booklet, *Tested Activities for Prevention Committees*, available free from the Federation of Mutual Fire Insurance Companies, 20 North Wacker Drive, Chicago, Illinois. In addition, both the National Fire Protection Association (NFPA), and the International Association of Fire Chiefs (IAFC) provide special packages containing fact sheets, posters, spot announcements, pamphlets, handouts, and other material.

Exercises (456):

1. To assure maximum coverage of personnel, which groups or organizations should be involved in the competitive programs of fire prevention?

2. Which program is usually endorsed by the Commander's Fire Protection Council?

3. A program directed toward the special hazards involving Christmas decorations, trees, etc., would be what type of campaign?

4. What is a monthly fire safety campaign?

5. What fire prevention program is streesed by Presidential proclamation?

457. Explain the value of visual aids in fire prevention and show how they may be obtained.

Visual Aids. The construction and use of visual aids in the presentation of fire prevention educational programs will require much effort, imaginative thought, and the support of numerous base level agencies. Often times those of us who are responsible for conducting these programs totally disregard the support these other agencies can give us, and the end result is somewhat less than a professional effort.

The following agencies can render assistance if they are approached in the proper manner and by using the proper coordination techniques of the fire protection supervisor.

Support Agencies. Base graphics personnel are skilled artists who have at their disposal the necessary equipment, tools, and materials to construct signs, graphs, and flip charts.

The base photo lab can assist through their skills and equipment. Often times they can send photographers to take pictures of fire hazards and unsafe practices—these pictures to be used at command briefings or at training sessions. This agency can also be asked to provide film and its subsequent processing so that you may take various pictures (color slides) that will aid you in a fire prevention lecture.

The film library can provide you with projectors, screens, and fire prevention topic films from the Air Force film library service.

Imaginative thought and careful planning is the key to a successful program. These agencies normally will not come to you offering their help; therefore you must seek out their assistance.

Promotional Materials. In addition to Fire Prevention Week material, the NFPA and IAFC provide promotional materials for use year round. Numerous commercial organizations and printers can also provide special items such as paper napkins, coasters, match books, special stationery, etc., printed with fire prevention slogans or appropriate scenes. It is often possible to arrange for the Officer, NCO, and Airman Clubs to purchase and use these items. The Base Exchange may have their book matches printed with a fire prevention slogan. Numerous national insurance companies provide fire prevention posters and handouts, many of them free. Many films and slides on fire prevention subjects are available for loan or purchase. One source list of these is the NFPA publication, Fire Control Film List.

Exercises (457):

1. How do visual aids enhance a fire prevention program?

2. Who should make the request of support assistance in the development of visual aids?

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3. Which section should be requested to assist in the development of graphs and flip charts?

4. How may the photo lab render assistance?

5. Where should you go to get projectors and/or screens for use in making a fire prevention presentation?

5-2. Presenting Fire Prevention Training

The ability to speak effectively is one of man's most longed for desires. It is the ability to stand on one's feet and transfer knowledge and thought to others, it is the ability to lead (with your own planned arguments) groups or individuals to a decision. The ability develops courage, poise, confidence, and prestige for the speaker.

The three main fundamentals of effective speaking are: (1) preparation, (2) enthusiasm and confidence, and (3) presentation.

Each of these areas is as important to each other as is each wheel on an automobile. Without thorough preparation you cannot have a full degree of enthusiasm or confidence; and enthusiasm and confidence are produced through your thorough knowledge of the subject to be presented. A complete preparation will produce a better presentation. The presentation will reveal the preparation.

458. Briefly explain how to prepare a speech, and explain what the parts of a speech are.

Preparation. Most effective speakers acquire proficiency through long preparation. Preparation is parallel in importance with knowledge of the subject. In addition to knowledge, there must be a purpose. This purpose is usually thought of (in speech terms) as an objective. The objective of the speech is what exactly you want the listeners to comprehend. Thinking of the objective or purpose for the speech, class, or lecture will have to be your first consideration and the first thing you put down on paper. Developing meaningful and usable objectives can be accomplished by putting oneself in the place of the listeners. By doing this, you will think of questions that the people in the audience may ask. These answers can be incorporated in the lesson to make a more complete lesson. In stating the objective, the preparer should keep in mind certain "rules." Focus your attention on the needs of the participants and limit the subject to accomplishing the goal. After choosing your objective, develop your speech around the accomplishment of that objective.

Research. With the objective in mind, the would-be speaker now proceeds to the next step—gathering material on the subject. Three sources of information are especially helpful: personal knowledge and experience; the knowledge and experience of others; and written information, regulations, manuals, books, etc.

The speaker should start the preparation with what he already knows of the subject and then he must make a survey of what he doesn't know. From this survey, make a checklist of areas in which further research and study is needed. Next, turn to others who may be able to give suggestions and help. They may have ideas that you have not previously thought of. The speaker is now ready to do primary research. He now knows what aspects need study. He will look for research material in a library. If the speaker has narrowed the subject properly, research of a relatively small part of the total subject will be needed. As the speaker is researching the material, he must be careful to see if the gathered material is relative to the objective.

What should the audience know about the subject? What ideas must the speaker get across if the objective is to be met? From the material gathered, the speaker makes a list of all ideas that might be important, without attempting to evaluate or to expand them at this point. Simply a word or a phrase is all that is needed. Now an evaluation of material is necessary. Some ideas or material can be discarded as unimportant or irrelevant. Usually the speaker finds that the ideas keep falling into two or three categories. These are the main ideas. The final step in preparation is to outline the ideas.

The outline. The outline will serve two purposes. First, it will make the material conform to a logical sequence. Secondly, the outline can be used as a guide during the speech so that the speaker need not memorize the entire speech. Many successful speakers consider their speeches to be only as strong as their outlines. There are three "inherent parts" of a speech: the introduction, the body, and the conclusion. The body of the speech covers the speaker's main ideas, the things he wishes to communicate to his listeners. The introduction and the conclusion serve special purposes.

Included in the introduction itself is the attention step, the motivation, and the overview. The attention step will take a considerable amount of thought. Catching the attention of the audience is primary. They must be made to think upon the subject matter to be presented. To do this, the speaker may use various techniques.

Ideally the attention step focuses the attention of the audience on the subject and the speaker. The speaker must then hold the audience's attention by showing the need for the information to be offered by showing why it is to the audience's advantage to listen. Motivation then is simply another part of the introduction. The third and final portion of the introduction is the overview. After the audience has been motivated to listen, they should be told what is to be covered in the speech. This overview simply alerts them to the main points. After the listener's attention has been gained, after he has been told why he should listen and what main points to be aware of, the speaker can then proceed into the body of the speech, the actual presentation.

The body contains all the gathered information and is used to inform the audience. This portion will naturally take the most time. The body should be organized into a logical sequence, using your main ideas and all support ideas, thoughts, and material. The third and final section of the speech is the conclusion.

The conclusion is by no means the least important section. In a speech format, there is not one section that is more or less important than the other. All sections work in conjunction. The basic function of the conclusion is to summarize main points that were presented in the body. The more a subject is repeated, the more chances for the listener to remember. The audience or listeners must also be remotivated. To remotivate is to reemphasize to the audience the importance not only of remembering the material but also of using the information. It is the using of this information that we, as speakers, strive to cause. We want the audience to walk away with something they can and want to use. The last section in the conclusion is the closure. It also is not easy to write. Careful thought must be put into the closure. The words last heard by an audience are the most likely remembered. Keep the closure short and to the point. Never make the statements "in conclusion," "to close," or "one last point." When these statements are made, the audience automatically prepares to leave. Whether they leave physically, they may have already left mentally.

Exercises (458):

1. What is the objective of a speech?

2. What is the first step in preparing a speech?

3. When should you start to gather material for a speech?

4. What are three especially helpful sources of information when gathering information for a speech?

5. What is the final step in preparation for a speech?

6. What two purposes does an outline serve?

7. What are the inherent parts of a speech?

8. What is included in the introduction part of a speech?

9. In what part of a speech do you put all the information gathered through your research?

10. What is the basic function of the conclusion?

459. Tell how to make a speech presentation, and tell what effect given factors have upon the presentation.

Presentation. After all the information has been gathered in outline form, the speaker then uses this outline to present the subject. Should the speaker simply "read" the outline or should thought be put into how to present the material? No matter how well a speaker has planned, organized, and supported ideas for a lecture, the real test comes when the material is presented to the audience. Proper delivery can give ideas dignity, force, and effectiveness. Through skillful use of voice and body, the speaker can project ideas and accomplish the objective. The test of a good delivery is whether the speaker holds the attention of the audience. Anything in the delivery that holds the attention away from main ideas is detrimental to the objective. This shows the importance of the attention step in the outline, as previously mentioned. Attention is drawn away from the objective by distracting mannerisms of the speaker, such as jingling of coins, playing with pencils, chalk, or pointers, profanity, smoking, and speaking in a monotone.

Delivery can be improved through practice. Some suggestions for improving the delivery follow.

Visual contact. Some speakers have a hard time looking directly at their audience. This fails to develop a sense of communication with the audience and is a common fault. The lack of communicative attitude seriously weakens any presentation. Visual contact should be made for several reasons:

- Gives each individual the feeling that he is being included.
- Keeps the audience tuned in.
- Gives the speaker an idea of how his material is getting across. Facial expression tells a great deal of the mental attitude of the listener.
- The speaker is talking to and with the audience, not at or in front of them.

Forget oneself. Fear or timidity is one reason a speaker will not have eye contact with the audience. Such a reaction can be overcome by forgetting oneself and by seeking opportunities to speak before others.

The speaker must be sincere. Sincerity results from a deep and abiding belief in the importance of the subject and in the correctness of the information. This reveals itself through voice, action, and facial expression. A speaker cannot maintain the look of sincerity if he is not sincere. If the audience feels that the speaker is sincere and has enthusiasm, they will also believe.

Show enthusiasm and confidence. Enthusiasm and confidence are contagious qualities and both go far toward winning a favorable response. If a speaker does not build confidence in the subject matter and if he is fearful, listeners are likely to reject the ideas presented no matter how worthwhile they may be.

Voice control. The voice is used as an index to human characteristics and physical condition. The voice should be under control by the speaker. The voice control must not be too weak or too strong. The voice can be used to emphasize points. A speaker who talks in a monotone, a tone that never changes, will find his listeners falling asleep or becoming very bored. The listener should learn to control his voice range.

Be prepared to speak. A speaker who is thoroughly prepared should still consider using notes. With a carefully prepared speech and outline, the speaker should have no difficulty. The speaker who has not put a great deal of emphasis on preparation may find that the notes become, instead of a guide, a crutch. Notes used correctly can have the following advantages:

- Ensure accuracy.
- Eliminate memory of entire subject.
- Essential in reporting complicated material.
- Help keep the speaker on the track.

Notes. Notes should be used sparingly. The effective speaker has selected his subject after considering his audience. He has decided the objective to be accomplished. He has formed the speech around it, and has put this gathered information into an outline form. Now he delivers the speech directly and sincerely, uses voice and body to reinforce ideas and purpose, but he uses notes only when he must!

Exercises (459):

1. How may speakers give their ideas dignity, force, and effectiveness?

2. How may a speaker project ideas and accomplish the objective when making a speech?

3. How is attention drawn away from the objective of a speech?

4. How can you improve your delivery of a speech?

5. What is a common fault of speakers that fail to develop a sense of communication with their audience?

6. How may you, as a speaker, overcome fear or timidity when making a speech?

7. Why should a speaker be sincere when making a speech?

8. The voice is used as an index to what?

9. When could notes become a crutch and not a guide in giving a speech?

10. When should notes be used during a speech?

5-3. Mutual Aid Agreements

The night of the big fire has arrived. Is your department ready? You and your fellow base fire protection specialists are confronted with a major warehouse conflagration. Does your department have enough men and firefighting vehicles to combat it? The alarm center operator has both hands full; we just finished handling a declared aircraft emergency, and now two structural fire alarms have been received. Can your department control it only with available base equipment or will you need deluge guns, snorkle trucks, or large-volume monitor nozzles?

Your department's requirements for additional personnel and equipment can, in most cases, be satisfied. There is a ready source of help available for assistance with high-value fires, widespread fires, multiple alarms, specialized fires, or other situations that are beyond your department's ability to handle. Personnel, tools, vehicles, and other needed equipment can be made available by surrounding communities through mutual aid agreements.

As fire protection specialist, you may be called upon to prepare, or assist in preparing, mutual aid agreements for your installation. This is a piece of very important business. You would do well to understand what is involved, for you are not only acting on behalf of your department and your installation, but in the name of the Air Force as well.

460. Indicate whether given statements concerning mutual aid agreements are correct. If a statement is invalid, correct it.

Mutual Aid Requirements. A mutual aid agreement is just what the name implies; an agreement between two fire protection organizations to help each other when needed. In order to have a successful *mutual* aid agreement, it must be advantageous to both parties.

Air Force Regulation 92-1, *Fire Protection Program*, has this to say on the subject of mutual aid agreements, ". . . may enter into reciprocal agreements with any fire organization, including an airport operator with a firefighting capability, for mutual aid in furnishing fire protection for property normally protected by the installation. . . . ." There are certain requirements, however, that must be met in order for an Air Force fire department to become involved in a mutual aid agreement. AFR 92-1 clearly states the requirements that must be met. Remember, this is a mutual agreement. Your department, as the Air Force's representative, must meet the civilian department's requirements also.

In simple terms, the conditions that must exist in order to warrant a mutual aid agreement with a civilian fire protection organization are as follows:

(1) Available U. S. Air Force fire equipment is not adequate to meet all needs of the installation.

(2) The fire organization with which the agreement would be made can furnish one or more pieces of manned fire apparatus when there is no emergency in the area protected by the organization.

(3) The fire organization could respond to calls under the agreement by having apparatus at the installation no more than 30 minutes after being notified, or the fire organization has special purpose apparatus that may be needed even though more than 30 minutes may elapse between notification and arrival at the scene.

(4) The apparatus that the fire organization would make available to the Air Force is of adequate standards in hose laying, pumping capability, and appliances.

Now let's expand on these requirements and see what they mean to your department. The first condition deals with the adequacy of your department to meet all possible fire emergencies. As a general rule, few, if any, Air Force fire departments have enough equipment to meet and successfully combat a major fire, a conflagration, or several simultaneous fire emergencies. On this point, at least, most base departments would benefit from a mutual aid agreement.

The second condition deals with the ability of the civilian organization to provide at least one piece of manned firefighting equipment. Obviously there would be no point to an agreement if your base could not expect to gain additional equipment. However, even if the civilian organization could normally provide equipment; in times of emergency involving their own area of responsibility, they may be unable to assist you.

The third point, the one dealing with response time of equipment, is very important. This condition covers two factors. First, there is the obvious one of assuring that equipment, when needed, would be able to reach your fire emergency in time to be of value. The second factor is of equal importance, but is a little more complicated. Response time in excess of 30 minutes is permitted if specialized equipment is involved. There could arise emergencies that may require special chemical or mechanical apparatus. This could be apparatus that is available only from fire protection organizations outside the area that you would normally consider for mutual aid agreements. If your base is likely to require such equipment, and even though the response time should exceed 30 minutes, you would be wise to seek an agreement with an organization that could provide such equipment.

The fourth condition has to do with the quality of the equipment to be provided by the civilian fire protection organization. You would be both foolish and in violation of the regulation to enter into an agreement and thus depend on assistance from a civilian organization that could not provide firefighting equipment that would meet or exceed your department's requirement for mounted equipment, nozzles, hose, and pumping ability.

In summary, we find that these are those four conditions that must be met by the civilian fire protection organization before you are permitted to enter into a mutual aid agreement: (1) your need for additional equipment, (2) the availability of the equipment, (3) response time, and (4) the quality of the offered equipment.

There is a fifth condition that must also be met and that is: the agreement must be in the best interest of the U.S.A.F.

Another important point about mutual aid agreements is on- and off-base coordination. Since your base may be called upon to provide equipment for off-base fire emergencies, as well as provide for civilian fire equipment coming to your installation, you must secure the cooperation of other base and local facilities that may become involved. When you are leaving your base, you come under the authority of local and state law enforcement procedures. Prior to your first off-base run, you should have already established a working relationship with local law enforcement agencies.

Of equal importance is the necessity of coordinating a mutual aid agreement with other offices on your base. Can you picture the results if civilian equipment answers your request for mutual aid, and then are stopped at the gate because no one has cleared their entrance with the security police?

In order to have as smooth an operation as possible, you should visit the civilian organization with which you have a mutual aid agreement and settle (preplan) as many anticipated problems as possible. Likewise, representatives of the civilian fire organization should be invited to visit the base. At this time, you should have present all the people from all interested base offices.

The Mutual Aid Agreement. Now that you understand the purpose and requirements of a mutual aid agreement, you should become familiar with the formal agreement itself. AFR 92-1 contains an illustration of the format of a normal mutual aid agreement. This is the only format that can be used to enter into a mutual aid agreement at base level. Any deviation from this format must be approved by Headquarters USAF.

Remember, a mutual aid agreement is designed to be a "two-way street." Your base can enter into agreements with as many different civilian fire protection organizations as would be in its best interest. It would be just fine if you could count on help from every fire department around your base. But there is a price to pay for this potential help. If you have agreements that makes civilian firefighting help available to your base, you must be ready to send help to all their different fire emergencies. Don't stretch your resources too thin.

It would be unwise to enter into mutual aid agreements with so many different organizations so that your equipment and men would constantly be answering off-base fire calls. The number of civilian fire organizations with which you enter into mutual aid agreements depends entirely on your individual needs. You should have enough to provide sufficient help when needed, but not so many as to cause an inconvenience. After all, mutual aid is just one part of your overall fire protection responsibilities.

Exercises (460):

If one of the following statements is correct mark it True; if it is False, correct it.

___1. As its name implies, a mutual aid agreement is an agreement between several fire protection organizations to provide each other with assistance when needed.

___2. One of the conditions which must be met before a base can enter into a mutual aid agreement is that the available U.S. Air Force fire equipment is not adequate to meet all needs of the installation.

___3. Unless the fire organization with which your base has a mutual aid agreement has special purpose apparatus that may be needed, the responding fire organization must have apparatus at the installation no more than 30 minutes after being notified.

___4. The apparatus that the other fire organization makes available to the Air Force must be of adequate standards in hose laying, pumping capability, and appliances, and must carry a five-man crew.

___5. Once the four conditions of the mutual aid agreement have been met, your base may enter into a mutual aid agreement with other fire organizations.

___6. Your mutual aid agreements may be of little value if you do not coordinate them with law enforcement and other governing/administrative agencies both on and off base.

___7. All the conditions have been met for your department to enter into a mutual aid agreement with the Chestnut Grove Fire Department. You must now go to AFR 92-2 for the proper format in which the agreement must be made.

___8. The number of fire organizations with which your department may enter into mutual aid agreements should be governed by the needs of your base.

CHAPTER 6

Fire Investigation

IN AREAS where extensive investigations have been carried out, it has been found that about 1 of 15 to 20 fire alarms (20 to 25 percent of all fires involving a loss) were incendiary fires. These figures are national but we're sure they apply to the Air Force as well. The monetary loss, however, is the one that hits hardest, since this is estimated to run from 30 to 50 percent of our annual national fire loss. Since fire loss is a billion dollars a year, it appears that some $400 million of this fire loss might properly be attributed to arson.

It is easy to see why arson is considered by many to be the most costly crime in the country today. In arson, there is virtually no salvage or recovery; ashes are a total economic loss to the country.

Considering the scope of investigation, it is wise to evaluate our own program for investigating fires. On the national level, only about 1/2 of 1 percent of all fire protection people are assigned to fire investigation, yet up to 40 percent of our annual fire loss is attributed to the wrong cause or is undetermined. With the rising fire loss and with fire incidents on the incline in the Air Force, it is imperative that Air Force fire protection personnel receive thorough training in the "art" of fire investigation. We, as firefighters, must be able to determine the cause of fire before we can initiate corrective action and deter new fire occurrences.

6-1. Investigations

One of the most difficult problems to solve is to determine the cause of a fire, since the flames generally consume any evidence of what occurred. For this reason, the cause of most fires cannot be determined without a long and careful investigation.

Firefighters often make snap judgments at the scene as to the cause of a fire, without adequate evidence or sufficient investigation on which to base their decision. Apparently there is a natural reluctance to admit that they do not know the cause of the fire, since few fires (approximately 4 percent of those reported) are listed as "cause unknown." Instead, the fire is attributed to various causes without apparent regard to actual evidence or to the lack of it. Some of the favorite causes listed by firefighters, when they are not certain of the actual cause, are faulty wiring, children playing with matches, spontaneous combustion, rats nibbling on matches, sparks from stove, defective flue, burning rubbish, and careless disposal of smoking materials.

The very general, indefinite nature of these "causes" indicates that, in most case, they are based on assumptions, guesses, or vague possibilities, rather than on evidence. This material will assist you in performing an investigation to determine the cause and origin of a fire.

461. Given a list of statements concerning fire investigations, match the statement with the type of investigation it is most closely associated with.

Requirement for Fire Investigation. The responsibility for conducting a fire investigation is established in AFRs 88-10 and 92-2. In accordance with Air Force policy, all fire incidents must be investigated; however, the specific requirements vary with the incident.

Only by determining the causes and by recommending corrective action can the Air Force reduce fire incidents. No matter how small, fire must be investigated. Fire investigations provide authorities with information needed to guide fire prevention educational programs, help fire inspectors in spotting and eliminating new or previously overlooked hazards, and developing meaningful information for training fire protection personnel.

Types of Fire Investigations. Essentially there are three types of investigations: the basic (on-the-spot) investigation, the technical investigation, and the arson-sabotage (special) investigation. The requirements for each are explained in the following paragraphs.

The basic (on-the-spot) investigation. This investigation, usually conducted by the Fire Chief and/or the Assistant Chief for Technical Services, along with the senior fire officer at the scene, will be accomplished on each and every fire incident. It is conducted to determine what property was damaged, what the causes and reasons were, the number and extent of injuries or fatalities, and the recommended correction action to prevent recurrence. The basic investigation will become the basis for the submission of AF Form 278, Fire Incident Report, and/or to establish the need for further investigation, as appropriate.

The technical investigation. The technical investigation is an investigation in depth of a fire incident to determine more specific details of cause, effect, and establish necessary corrective action. The investigation will be by local commanders or Major Air Command, as described in AFE 92-2 and dictated by the specific incident.

Local commanders will have technical investigation made under any of the following conditions:

(1) There is a suspicion of arson in connection with any fire.
(2) There is suspicion of negligence or violation of regulations.
(3) The cause of any fire is undetermined (to establish the most probable cause).
(4) There is evidence of negligence or mismanagement in the fire suppression or rescue operation.
(5) Loss of life or disabling injury occurs as a result of fire.
(6) Damage exceeds $25,000.
(7) When initiated or directed by the installation commander, the Major Air Command, or the Chief of Staff, USAF.

MAJCOM will have technical investigations made under any of the following conditions:

(1) Loss exceeds $50,000.
(2) Air Force vehicle fire incident has outstanding internal or public impact potentials.
(3) Multiple fatalities or injuries occur as a result of real property and material fire incidents.

Each base, wing, or higher level commander will appoint technically qualified and disinterested officers or civilians (one or more) to conduct the technical investigations required above. The report of investigation will be prepared and submitted in accordance with AFR 92-2 and sent through the same channels and for the same distribution of copies as specified for AF Form 278.

Arson-sabotage (special) investigation. The Office of Special Investigation will be requested to investigate those fires suspected of having been deliberately set, regardless of reason. This suspicion may be a direct result of the basic or technical investigation, or it may be brought about from outside knowledge. But, in any case, commanders requesting the Office of Special Investigation to investigate suspicious fires must make such requests promptly. The following criteria is extracted from AFR 92-2: "In deciding whether to initiate a special investigation, the commander should be aware of pertinent factors developed by his fire officer. If possible, all evidence will remain intact where discovered. (If it is disturbed during initial inquiry, carefully preserve it and turn it over to the OSI investigator. When necessary, guards will be required at the scene of suspicious fires to prevent destruction of evidence or for other possible leads.) It should be noted that commanders make the actual request for special investigation from the OSI. This is often initiated by the senior fire officer, through the Civil Engineer, Security and Law Enforcement personnel, or the Officer of the Day, as appropriate and as time permits."

Exercise (461):

1. Match the statements listed in column B with the type of fire investigation in column A with which it is most closely associated. Each statement may be used once, more than once, or not at all.

Column A

____ 1. Basic.
____ 2. Technical.
____ 3. Special.

Column B

a. The responsibility for conducting this type of investigation is covered in AFR 92-2.
b. This investigation will become the basis for the submission of the AF Form 278, and/or to establish the need for further investigation.
c. This investigation is conducted by the first-in crew chief and law enforcement officer.
d. A local commander will have this type of investigation if there is evidence of negligence or mismanagement in the

fire suppression or rescue operation.

e. The actual request for this type of investigation must be made by commanders to the OSI.

f. MAJCOM will have this this investigation conducted when fire loss exceeds $50,000.

6-2. Fire Causes

Every fire has a cause as well as a reason. While these terms are often used synonymously, they are actually quite different.

462. Indicate whether given statements concerning the cause of fire are correct. If a statement is invalid, correct it.

As far as fire investigation is concerned, they may be defined as: *cause*, that which made the fire start, and *reason*, that which led to the cause of a fire (a motive leading to an action).

Both cause and reason must be established to satisfactorily complete a fire investigation. The "cause" explains the existence of fire, or the WHAT of investigation; while the "reason" establishes the WHY of the fire and investigation. Both are required if we are to correctly classify the fire and, also if we are to provide guidance in establishing corrective action to preclude a recurrence of the incident.

Essential to the establishment of a fire cause is the knowledge of the physical aspects of fire; i.e., the phenomenon or chemistry of fire. More is required than just the knowledge of the three elements of fire (heat, fuel, oxygen). The effects of each other, the variations of change, the chemical aspects of fuels and oxidizers, the results of changes in temperature, and much more, are needed to pinpoint specific fire causes. This same knowledge will be found necessary to substantiate the suspicion of an incendiary cause, since all other causes of fire must be eliminated before we start assuming an incendiary cause.

The cause of a fire may be the malfunction of equipment, while the reason for that fire may be the lack of proper care and maintenance of that equipment. There are only four general classes of fire causes.

Natural. Fires caused naturally without human aid, such as lightning, spontaneous ignition, mechanical malfunction of equipment.

Accidental. Fire causes where human action is involved directly or indirectly, such as careless disposal of smoking materials or such as workers using weld-cutting equipment.

Arson. Fire as a result of the willful and criminal act of some person; i.e., incendiary fires.

Unknown. All fires which are not classified as to cause. There are three general classifications of fires: innocent, incendiary, and unknown. Innocent fires include both natural and accidental causes; incendiary fires include arson cases, regardless of reason; and, of course, the classification "unknown" covers all fires of unknown causes.

Exercises (462):

If one of the following statements is correct, mark it True; if it is False, correct it.

____1. As far as you, as a fire investigator, are concerned, the word "cause" may be defined as "that which made the fire start," while "reason" means "that which led to the cause of a fire."

____2. Both the "cause" and the "reason" are required to correctly classify the fire.

____3. During a fire investigation, most other causes of fire must be eliminated before assuming an incendiary cause.

____4. When a fire results due to the malfunctioning of equipment, the cause for that fire may be the lack of proper care and maintenance of the equipment.

____5. When classifying the cause of a fire that resulted from mechanical malfunction of equipment, you would classify that fire as accidental.

____6. Any fire (other than arson) which results from either direct of indirect human action should be classified as accidental.

____7. If after you have completed your investigation of a fire, you cannot establish the exact cause of that fire, then that fire should be classified as unknown.

6-3. Conducting Investigations

Technical investigations and arson-sabotage investigations are generally directed and conducted by personnel outside of the civil engineering organizations, with the occasional assistance of one of the responding senior fire officers. Therefore this discussion will be primarily limited to the conduct of the basic fire investigation defined above, with only minor emphasis on other considerations.

463. Given a series of incomplete statements concerning personnel that make fire investigations, complete the statements by filling in the correct word(s) and/or phrase(s).

Incomplete investigations are generally the result of bad planning and organization. Like any other phase of fire protection, preparation is an important factor in investigation. Good preparation begins with the selection of personnel who will perform the investigation. And this same kind of good preparation must remain important throughout all phases, including the filing of the final report. While all of the following are important items of consideration in planning and accomplishing the investigation, they are not necessarily listed in order of sequence. Each incident is unique.

The persons who are to examine and inspect the fire scene should be carefully selected and limited in number. The following persons should be included as necessary, depending on the circumstances; Base Fire Marshal, Base Fire Chief, Assistant Chief for Technical Services, fire inspector responsible for the specific building, senior fire officer at the fire incident, base photographer, and base utilities personnel (particularly an electrician).

The first four individuals provide the technical experience for the investigation. The senior fire officer from the fire incident is present to explain what was observed during the fire and to report on the mechanics of extinguishment of the fire. The photographer should provide complete coverage, beginning with pictures during the firefighting operations, if possible, and including exterior, interior, special features, or circumstances, and the activities of the investigators at work. The utilities personnel may provide technical assistance, particularly as to condition of electrical circuits and appliances.

Exercises (463):

Fill in the blanks in the following statements.

1. The persons who are to examine and inspect a fire scene should be carefully __________ and __________ in number.
2. If you, as a fire chief, have the proper selection of personnel on a fire investigation team, you should rely on the ________, ____________________, and ____________ to provide the technical experience for an investigation.
3. Should you require someone to be present during your investigation to explain the mechanics of extinguishment of the fire, that person should be the __________ __________ __________ from the fire scene.
4. When technical assistance is required as to the condition of certain electrical circuits and/or appliances, you should consult with the __________ __________.

464. Ascertain the validity of given statements concerning actions that should be taken prior to starting a fire investigation. Should a statement be found to be invalid, correct it.

It has been suggested by leading authorities that the fire investigation team possess an "evidence kit." This kit provides equipment for use in the investigation and for the preservation of any evidence found at the scene—after that evidence has been photographed in its original location. It may seem a large variety of items but actually most items stack within each other and make a relatively small package. Some of the suggested items include the following:

Special clothing (coveralls, gloves, boots). To protect your uniform.

Flashlight and electric lantern. For use in darkened areas.

Measuring tape and small ruler. Used for making measurements.

Labels (gummed and stringed). Used to identify items.

New or sterile glass jars with rubber airtight seals. Used for the collection of samples.

Envelopes, boxes, plastic bags, metal cans (assorted sizes). Used for the collection of samples.

Cotton batting or packing. Used to protect samples.

Wrapping paper. Used to protect samples.

Sealing wax and tape. Used to seal samples packages, etc.

Marking pencil, crayon, and ink marker. Used to mark sample packages.

Knife. Used to gather samples, probe, etc.

Axe. Used to gather samples, probe, etc.

Crowbar. Used to gather samples, make area safer, mark off an area, etc.

Before beginning the investigation, each person on the investigation team should be cautioned to refrain from smoking or discarding smoking materials at the fire scene. Each should also be cautioned not to touch or remove any evidence, but to call the group together to witness the finding and to photograph and properly process the evidence. The "as-built" drawings or blueprints of the structure should be obtained from the civil engineers' office, and studied prior to commencing the investigation. Other ground rules, as the situation dictates, should be explained and discussed for all persons involved. Specific arrangements must be made, as necessary, for the following:

Gaining access to the fire scene.

Providing lighting for the entire area.

Removal of water and/or debris which might preclude access to all parts of the structure including attic and basement.

Having the necessary quantity and type of tools and equipment.

Shoring up floors and walls (or tearing them down) to assure that the area is safe and accessible.

Guarding the fire scene until the search, examination, and photography are completed. Protection must continue if the need for higher level investigation develops.

Exercises (464):

If one of the following statements is correct, mark it True; if it is False, correct it.

____ 1. You should have an evidence kit on hand before you start your investigation to provide equipment for use in the investigation and for the preservation of any evidence found at the scene of a fire.

____ 2. Before you begin an investigation, you should caution all cigarette smokers to refrain from smoking or discarding smoking materials at the fire scene.

____ 3. Each team member should also be cautioned not to touch or remove any evidence found before calling one other team member to witness the finding.

____ 4. Prior to commencing the investigation, the "as-built" drawings or blueprints of the building should be obtained from Civil Engineers and studied.

____ 5. You should make arrangements to have the walls and floors of the building shored up (or torn down) before your investigation is started.

465. Point out how and/or why given actions/functions are performed as a part of a fire investigation.

Fire Investigation. The art of investigation is a difficult one to teach; it is much easier learned through performance and through learning from one's mistakes. However, the following points have been picked up through experience by qualified investigators and are passed on for consideration.

When conducting a fire scene examination using the outlined procedures, it is imperative that an investigator take photographs, make notes and sketches, and gather and record evidence so that he may substantiate his findings and opinions for report purposes, professional testimony, and evidentiary value.

A fire scene examination will produce the most accurate results when the investigation follows basic steps.

Search systematically. Make a plan; have in mind what you will look for, the way you will look, and what you will do with each item found. Be thorough, complete, and orderly.

Observe. Use your eyes, ears, nose, and camera to note conditions. Observe the fire and also the spectators. Observe the remains and debris. Watch the firefighters during overhaul phase, in the event they uncover evidence.

Take photographs. The camera records more details than the eye. Establish visual reference through numerous photographs. Photograph each area several times during the various phases of investigation. Infrared photography may prove extremely valuable since it is sensitive to differences in heat.

Work by the process of elimination. Establish a checklist and check off each item. Settle one item before attempting another, if at all possible. Avoid backtracking.

Check and verify. Don't assume or take for granted. Don't jump to conclusions.

Take notes. Memory isn't good enough. Write down all details.

Draw diagrams. Amplify notes with diagrams depicting locations of incidents described.

Exterior. Examine the exterior of the building. Determine where the fire vented first by comparing burn, char, smoke, and heat patterns around windows, doors, and roof. Examine doors, door butts, and locking devices to determine door position and security during fire progress. NOTE: Remember that a door could have been closed during early stages of the fire and opened later during fire progress, thereby depositing smoke and heat stains which may be deceiving.

In addition, look for the following:

(1) Exterior points of origin.
(2) Unusual burn patterns (flammable liquid).
(3) Tools and flammable liquid containers.
(4) Footprints and scuff marks at suspected points of entry.

Interior. Examine the interior of the building. Conduct a cursory examination or general survey of the entire structure interior for the extent of fire damage.

Establish the class of fire duration (brief or long) and the approximate burn time by checking the following; (1) window glass condition, (2) depth of wood char, at or in close proximity to the point of origin; (3) penetration of fire resistive rated wall coverings by fire; and (4) electric clocks that have been stopped by fire damage. (Note the time stopped and compare with alarm time.) The time factors should be estimated and considered as approximations only.

Exercises (465):

1. Why must an investigator take photographs, make notes and sketches, and gather and record evidence?
2. Why should firefighters be watched during overhaul operations?
3. How may infrared photography prove valuable in your investigation?
4. How would you determine where the fire first vented?
5. Why would you conduct a cursory examination or general survey of the entire structure?
6. The depth of wood char at, or in close proximity to the point of origin, will help establish what?
7. How accurate are "stopped clocks" in fire investigation?

466. Explain how to determine the point of origin of a fire.

Examine the entire interior of the building and determine which room or area has received the most severe fire damage. Generally this will be the room or area where the fire burned the longest and will very likely be where it originated.

Determine the level of origin within the room by examining and comparing the bottom side of tables, shelves, and chairs.

Examine the ceiling and look for the following patterns: (1) fire penetration, and/or (2) heaviest fire exposure.

Examine light bulbs within the room. Light bulbs begin to swell and lose shape at about 900° F when exposed to heat for 10 minutes or more. The side of the bulb which is initially exposed to heat will swell or bulge and actually point to the area of fire origin.

Examine walls within the room and look for fire patterns or fire cones. Keeping in mind that fires generally burn upward and outward, they leave corresponding fire patterns on walls as a result of heat transfer through convection and radiation. The steepness or relative pitch of the angle seen on the fire cone is indicative of the type of burning, i.e., smoldering or flaming.

Debris. Examine the fire debris and the floor in the following manner.

Conduct a detailed search of the debris, one section at a time, examining it layer by layer until the floor is reached.

Completely clean the floor of all debris and char dust. When finished, the floor and floor covering should be clean enough to observe and photograph the significant burn and char patterns and should be dry.

Carefully reconstruct and replace furnishings and other articles in their original positions by using burn patterns and corresponding protected areas. During fire progress, legs and bases of furniture and other items on the floor will protect the floor, leaving unburned marks which will aid in repositioning.

Examine the floor covering and floor for significant patterns.

Furnishings. Examine fire damaged furnishings.

Upholstered furniture, couches, chairs, beds, etc. Two general types of burn patterns will be encountered. One will involve only a surface burning of the item, with consistent damage over the surface. Examination of supporting springs will disclose that tension still exists. The second type of pattern will involve a deep penetration of one portion with corresponding collapse of springs and frame destruction. Spring collapse is caused when the heating process occurs over an extended length of time, causing the springs to lose their tension and collapse of their own weight. The first pattern is indicative of the presence of a smoldering source of ignition.

Television sets and table radios. If the cabinet is destroyed, chassis warped, and components melted with corresponding burn and char patterns on the wall and floor, this is indicative of origin and a careful examination of the debris should be made to determine if the appliance was, in fact, plugged in. These appliances do cause fires, even if turned off.

Drapes and curtains. Fires originating in drapes or curtains leave a distinct burn pattern on the window frame, at the base of which is located the point of origin. In addition, after the drape or curtain burns free of the rod, it will fall to the floor and leave a burn or char pattern at that location.

Kitchen range. Cooking fires which originate on ranges are readily identified by the distinctive fire cone coming upward from the burner involved. These fires generally will make rapid progress because of their open flame nature. Damage to the kitchen area will be extensive.

Exercises (466):

1. What section(s) of a building should be examined to determine the room or area that has received the most severe fire damage?
2. How can the level of the origin of a fire be determined?
3. An examination of the ceiling may show patterns of ______________ ____________ and/or ____________ ______ ______________.
4. Light bulbs may give you what information during a fire investigation?
5. The steepness or relative pitch of the angle of a fire cone may tell you what?
6. How should a detailed search of the debris be made?
7. How can you tell where furnishings and other articles belong in a burnt room?
8. A smoldering source of ignition in a stuffed chair is indicated by what?
9. Where do fires originating in drapes or curtains leave a distinct burn pattern?

467. Given a series of statements concerning evidence in fire investigations, indicate whether or not the statements are correct. If a statement is invalid, correct it.

Evidence. Sometimes evidence and proof are used as interchangeable terms; however, they are not the same. Evidence is defined as "any information so given, whether furnished by witnesses or derived from documents, or from any other source." Or more simply, "the facts that tend to prove something." Proof is defined as "sufficient evidence to establish a thing as true." There are various types, classes, and kinds of evidence. The subject will be treated here in a general way. Evidence, as discussed here, relates to any information, data, or physical material pertinent to the cause and origin of a fire.

Experienced fire investigators search a fire scene with a systematic plan, as mentioned above. In general they will be looking for the following:

- Evidence of the cause and origin of the fire.
- Evidence which indicates or tends to prove the responsibility for the fire such as negligence, neglect, omissions, errors, and violations.
- Evidence of a suspicious nature.
- Evidence of incendiary origin. Evidence which might indicate or tend to prove the identity of the fire setter.

All physical evidence, whenever and wherever found, should be photographed immediately upon discovery and in the exact state discovered. In addition, each piece of evidence must be properly witnessed and recorded. If evidence relates to a suspicious cause and origin, then immediate steps must be taken to protect the evidence intact and at the site, if possible, by notifying Security Police. Do not remove evidence of a suspicious nature, except as a last resort to protect its integrity.

If physical evidence must be removed, as explained above, extreme care must be taken to avoid contamination. Sterile, airtight containers should be used, with minimum handling. Each person handling the specimens should sign, initial, or otherwise properly identify it. Assure all evidence of suspicious nature is identified as soon as practicable.

The analysis of evidence by a scientific laboratory is quite common to fire investigation. Generally, access to laboratories is made through the Security and Law Enforcement or Office of Special Investigation personnel.

The most common use of a laboratory is the extraction and identification of flammable liquid accelerants taken from samples or specimens. However, the lab may provide additional assistance through identifying blood stains, tracing materials and equipment as to type and ownership, identification of tools and equipment by their telltale marks and impressions, and similar types of analysis.

All firefighters should be instructed to be observant of the types of evidence mentioned above while they are actually fighting fire. Senior fire officers should be notified immediately upon finding any evidence or irregularity, and all effort must be made to avoid disturbing such evidence with heavy firefighting streams. The entire area should be protected and the evidence preserved for as long as necessary.

Exercises (467):

If one of the following statements is correct, mark it True; if it is False, correct it.

___1. As discussed in the text, proof relates to any information, data, or physical material pertinent to the cause and origin of a fire.

___2. While experienced fire investigators search a fire scene, they are looking for evidence which indicates or tends to prove the responsibility for the fire such as negligence, neglect, omissions, errors, and violations.

___3. All physical evidence found at the scene of a fire should be photographed upon discovery and in the general state discovered.

___4. Evidence of a suspicious nature should not be removed from the scene, except as a last resort to protect its integrity.

___5. To avoid contamination of physical evidence which must be removed, you should use clean glass jars.

___6. Generally, access to laboratories for the analysis of evidence is made through the base fire marshal or the base fire chief.

___7. The extraction and identification of flammable liquid accelerants taken from samples or specimens is the most common use of a laboratory in fire investigation.

____8. If firefighters discover evidence while fighting a fire, they should notify the senior fire officers immediately and the area should be protected for at least 12 hours.

468. Complete statements concerning the firefighter's role in fire investigations.

The fire department's first job on arrival at a fire is to rescue endangered personnel and extinguish the fire. Determining the actual cause of the fire, whether natural or suspicious, must necessarily remain a secondary, although very important, responsibility. However, the firefighter can provide valuable information to subsequent investigators by becoming more aware of those facts of particular interest to fire investigators. This is especially true of the working firefighter rather than of the senior fire officers, since the working firefighter is more closely associated with the firefighting operation.

The following are areas in which the firefighter can provide information.

Alarm Information. The alarm center operator can provide the following information:

- Exact time and date of alarm.
- Method of transmitting alarm (fire phone, administrative phone, in person, etc.).
- Nature of alarm (exactly what was reported: fire, explosion, explosion and fire, etc.).
- Identification of person giving alarm (how did he learn of the fire and what was he doing at the time of the alarm).

Approach. Upon approaching the fire, the responding crew members should be alert to the following:

Weather conditions. Weather conditions (rain, snow, ice, wind velocity and direction, visibility, temperature, humidity).

Traffic conditions. Traffic conditions, persons on street (note anyone hurrying from area, note dress of persons on street).

General conditions. General conditions of fire building (nature of construction, size, etc.).

Arrival. Upon arrival at the fire, crew members should notice some or all of the following; location of fire, was the fire inside or outside building, on what floor or floors, in what rooms, and/or coming through roof.

Color and density of smoke. The color of the smoke may often give an indication of what is burning:

White (common).
Yellow (sulphur or sulphur derivative).
Brown (chemicals).
Black (petroleum/hydrocarbon derivatives).

Density (heavy, thick, billowing to light, thin, wispy).

Color of flames. As with smoke, the flames tell a lot.

Color indicates temperature of burning (faint red is 900° F through blue white, 2250° F).

Abnormal color or temperature may indicate that an accelerant was used.

General size of fire. Last but not least, we must consider the size of the fire: Large or small, one room, one floor, entire building involved, and indication of separate individual fires.

It can be seen that it is essential that all fire fighters be alert and constantly aware of what is going on around them. They must be able to relate the facts of the fire with their own actions during each phase of the firefighting operation. They must not work mechanically; but rather, all actions should be deliberate and with purpose, so that recall of each action taken is elementary. One cardinal rule worth repeating is that every firefighter is responsible for reporting anything unusual or suspicious immediately to the senior fire officer at the scene. It should be noted that this is "privileged information" and cannot be released to others. The fact that every trained firefighter cannot also be a trained investigator does not mean that they cannot play a highly important part in the investigation process. On the firefighter, to a great extent, will rest the responsibility for performing certain important detection duties without which the trained investigator will always be seriously handicapped.

Exercises (468):

Complete the following statements.

1. A firefighter can provide invaluable information to investigators by becoming more aware of those ____________ and ____________ of particular interest to fire investigators.
2. The individuals who are most closely associated with the firefighting operation are the ____________ ____________.
3. As an investigator, you would expect the ____________ ____________ ____________ to provide you with information concerning the nature of the alarm and its method of transmission.
4. The responding crew members should be alert to the ____________, ______, and ____________ conditions upon their approach to a fire scene.

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5. If the responding crew members tell you that upon their arrival they noted thick brown smoke issuing from the building, you would suspect that ________________ were involved.
6. If a firefighter tells you that he believes the fire was burning at about 900° F, the color of the flames should have been ______.
7. Abnormal color or temperature of flames, as noted by the firefighters, may indicate an ____________________ was used.
8. Firefighters must be able to relate the facts of the fire with ______________ ________ ________ during each phase of the firefighting operation.
9. The actions of all firefighters should be ________________ and with ________ so that recall of each action taken is elementary.
10. Every firefighter is responsible for reporting anything ____________________ or ____________________ to the senior fire official at the scene immediately.

Bibliography

Books

- *Fire Protection Handbook*, NFPA.
- *National Fire Codes*, NFPA.

Department of the Air Force Publications

- AFM 85-13, *Maintenance and Operation of Water Plants and Systems.*
- AFM 88-10, *Water Supply.*
- AFM 88-15, *Air Force Design Manual—Criteria and Standards of Air Force Construction.*
- AFR 92-1, *Fire Protection Program.*
- AFR 92-2, *Fire and Rescue Reports, Records, and Investigations.*
- AFR 127-101, *Ground Accident Prevention Handbook.*

NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB, AL 36112, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs.* TOs, classified publications, and other types of publications are *not* available. Refer to current indexes for the latest revisions of and changes to the official publications listed in the bibliography.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

400 - 1. False. Change "development proposals shown on installation master plan." to "actual requirements of the project."
400 - 2. True.
400 - 3. False.'Change "review" to "preparation."
400 - 4. False. Change "necessity for providing complete safety." to "occupancy classification."
400 - 5. True.
400 - 6. True.
400 - 7. False. Change "minimum" to "maximum."
400 - 8. False. Change "88-13" to "88-15."
400 - 9. False. Change "conflagration" to "life."

401 - 1. 1. e, g.
    2. a.
    3. d, f.
    4. c.
    5. b.
401 - 2. 1. a.
    2. f.
    3. c.
    4. e.
    5. b.
401 - 3. 1. b.
    2. c.
    3. d.
    4. e.
    5. a.

402 - 1. 1, c.
    2. d, e.
    3. a, f.
    4. b.

403 - 1. Relative degree of combustibility.
403 - 2. Type N., noncombustible; and Type C, combustible.
403 - 3. Type N, noncombustible construction.
403 - 4. Fire-resistive; protected noncombustible (light fire resistive); and unprotected noncombustible.
403 - 5. Conform to a definite period of fire resistance.
403 - 6. Contribute to the spread of fire.
403 - 7. Lesser; protected noncombustible (light fire-resistive).
403 - 8. Specific fire-resistive rating.
403 - 9. Type "N" unprotected noncombustible.
403 - 10. Type "C."
403 - 11. Three; (1) heavy timber; (2) ordinary construction; and (3) wood framing construction.
403 - 12. 2 hours; a stability under fire.
403 - 13. 6 inches; 10 inches; 8 inches in any dimension.
403 - 14. Masonry; reinforced concrete; 2 hours.
403 - 15. 1-hour fire resistance.
403 - 16. Wood framing construction.

404 - 1. 1. j.
    2. e.
    3. b.
    4. n.
    5. o; h.
    6. d.
    7. k.
    8. a.
    9. p.
    10. c; f.
    11. i.
    12. g.
    13. s.
    14. r.
    15. q.
    16. m.
    17. l.

405 - 1. 1. F.
    2. R.
    3. O.
    4. M.
    5.
    6. C.
    7. H.
    8. A.
    9. N.
    10. U.
    11. T.
    12. E.
    13.
    14. I.
    15. L.
    16.
    17. G.
    18. S.
    19. X.
    20. Q.
    21. B.
    22. V.
    23. W.
    24. P.
    25. J.
    26. K.
    27. D.

405 - 2. 1. h.
    2. l.

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3. e.
4. c.
5. j.
6. b.
7. i.
8. o.
9. a.
10. f.
11. d.
12. k.
13. m.
14. g.
15. n.

405 - 3. 1. h.
2. j.
3. k.
4. p.
5. m.
6. d.
7. l.
8. a.
9. q.
10. u.
11. e.
12. t.
13. i.
14. s.
15. g.
16. o.
17. c.
18. b.
19. z.
20. w.

406 - 1. True.
406 - 2. True.
406 - 3. False. Add "only" after concerned; and delete the period and add "is of no concern."
406 - 4. True.
406 - 5. False. Change "discharge" to "access."
406 - 6. False. Change "(alarm systems)." to "(sprinklers)."
406 - 7. False. Change "48" to "30."
406 - 8. False. Change "or" to "but not."
406 - 9. True.
406 - 10. False. Change "1 hour" to "one-half hour."
406 - 11. True.
406 - 12. False. Change "10" to "20."
406 - 13. True.
406 - 14. False. Change "occupant load" to "occupancy (use)."
406 - 15. 90. (200 x 30 x 3 = 18,000 sq. ft. (gross); (18,000 ÷ 200 = 90).
406 - 16. 30. (90 ÷ 3 = 30).
406 - 17. 1. (30 ÷ 30 = 1).
406 - 18. 6. (One at each end of each floor since no dead ends are allowed.)

CHAPTER 2

407 - 1. Operating principle.
407 - 2. Automatic fire detection and alarm systems.
407 - 3. Supplemental manual boxes.
407 - 4. Existing heat-actuated detectors.
407 - 5. Practicable.
407 - 6. Smoke detectors.
407 - 7. Building fire alarm system.
407 - 8. Operation of the system.
407 - 9. Coded signal.
407 - 10. Line side; main house switch.
407 - 11. Twenty or more.
407 - 12. Manually reporting fires.
407 - 13. 1,000 feet.
407 - 14. 150 feet.
407 - 15. 24 inches.
407 - 16. 600 feet.
407 - 17. 25.

408 - 1. Their cost must be justified by the present and future advantages of their installation.
408 - 2. The capacity of control by local firefighting forces or water supplies.
408 - 3. In areas not normally heated or where otherwise desirable due to climatic conditions.
408 - 4. When these facilities are of type "C" construction and justified by the importance of the service, the probably frequency and potential severity of fire damage, or the absence of similar facilities essential to the mission.
408 - 5. Only when the contents are combustible, or where operations create fire or explosion hazards.
408 - 6. Type "C" or "N" construction approximating or exceeding 20,000 square feet.
408 - 7. By fire walls or fire partitions.
408 - 8. Deluge-type systems.
408 - 9. A minimum of 45 minutes.
408 - 10. Where the total floor area including shops is less than 24,000 sq. ft.
408 - 11. In cabinets or other small enclosures housing critical material which is combustible or presents a fire or explosion hazard.
408 - 12. Portable fire extinguishing equipment.
408 - 13. When open-head deluge systems are used, when a closed-head sprinkler system is supplied directly from the buildings internal domestic water system, and on localized systems protecting small areas in the interior of large area buildings.

409 - 1. The type of signal that is transmitted to, and received at, some central location.
409 - 2. It indicates the location of the device that caused the signal to be transmitted.
409 - 3. From manually operated fire alarm boxes or stations.
409 - 4. A signal, coded or uncoded, is produced.
409 - 5. They permit manual transmission of fire alarm signals.
409 - 6. A combination of several systems.
409 - 7. The manufacturer's operation and maintenance manuals.

410 - 1. They act as actuating devices which cause the transmitter(s) to send signals indicating their operation.
410 - 2. (1) A power supply, (2) remote circuit wiring, (3) a local evacuation alarm circuit, and (4) the control mechanism and connecting terminals for internal wiring connections.
410 - 3. By a primary 110-volt ac power source and an emergency power source consisting of either wet-cell storage batteries or dry-cell batteries.
410 - 4. The signaling contacts open and close which produces groups of intermittent impulses within the alarm system circuit.
410 - 5. One.
410 - 6. By sending a one-round trouble signal.
410 - 7. One less than the number produced under normal operating conditions.

410 - 8. Throughout an entire building or only in the local area near the manual alarm box.
410 - 9. A glass part is broken, handle pulled, or the door on the alarm box is opened.
410 - 10. By a spring which is wound when the operating lever is pulled.
410 - 11. To heat, light, or smoke.
410 - 12. According to the manner in which they are triggered.
410 - 13. The movement of a bimetallic part.
410 - 14. When the preset temperature is reached, the disc changes shape and snaps out, causing the movable contact to touch the fixed contact.
410 - 15. The insulation has been softened from heat, allowing the twisted spring wires to contact one another making an electric contact.
410 - 16. The temperature rating is the value at which the fixed temperature element operates when a thermostat is heated slowly so that all parts are heated uniformly.
410 - 17. The expansion of heated air in a vented chamber.
410 - 18. By adjusting the air vent at the diaphragm assembly.
410 - 19. The energy created from a fire.
410 - 20. The rate-of-rise feature.
410 - 21. 15° to 20° or more per minute.
410 - 22. The small button on the outside of the chamber becomes a hole when the spring is released.
410 - 23. They are used where the type of fire anticipated is expected to generate quantities of smoke in advance of a temperature rise and work on the photoelectric cell principle.
410 - 24. A change of light intensity ratio between the two photoelectric cells.
410 - 25. The detector sensing and responding to infrared radiation.
410 - 26. By using a flame-detector tester; the flashing light of the tester is directed from the floor onto the detector to cause activation.
410 - 27. The activation phone's identification number is automatically registered on a signal board and remains visible until manually cleared by the alarm center operator.

411 - 1. Audible; visual.
411 - 2. 110-volt alternating current.
411 - 3. wet-cell storage battery.
411 - 4. Telephone cable.
411 - 5. Supervised.
411 - 6. Internal control wiring; devices at the receiver.
411 - 7. Buzzers, diaphragm horns, bells, or gongs.
411 - 8. recorder; takeup reel.
411 - 9. Signal impulse.
411 - 10. Automatic locking device.
411 - 11. Noncoded system.

412 - 1. False. Change "the intensity of the fire" to "faulty maintenance or service."
412 - 2. True.
412 - 3. True.
412 - 4. False. Change "horizontal" to "vertical."
412 - 5. True.
412 - 6. False. Change "cross mains" to "branch lines."
412 - 7. True.
412 - 8. False. Change 1½ inches" to "one-half inch."
412 - 9. False. Change "may be" to "cannot be."
412 - 10. True.
412 - 11. False. Change "water" to "foam"; and "foam" to "water".
412 - 12. True.
412 - 13. True.
412 - 14. True.
412 - 15. True.
412 - 16. False. Change "at least two control valves" to "only one control valve."
412 - 17. False. Change "globe" to "gate."
412 - 18. True.
412 - 19. True.
412 - 20. False. Change "globe" to "check."
412 - 21. False. Change "AF Form 1104" to "DD Form 1104."

413 - 1. 1. c.
  2. e.
  3. h.
  4. b; k.
  5. i.
  6.
  7. g.
  8. f.
  9. a; d.

414 - 1. Dry-pipe.
414 - 2. Dry-pipe valve.
414 - 3. Electric; hydraulic.
414 - 4. Differential.
414 - 5. 30; 45.
414 - 6. Delayed.
414 - 7. Rubber diaphragms; differential air plate.
414 - 8. Intermediate chamber; automatic drip valve.
414 - 9. Mechanical.
414 - 10. Air; diaphragm.
414 - 11. Type of valve; available water.
414 - 12. Central; unit.
414 - 13. Quick-opening device; 400.
414 - 14. Accelerators; exhausters.
414 - 15. 1; 2.
414 - 16. Fusing; sprinkler head.
414 - 17. Riser water pressure.
414 - 18. Drip-check; closed; alarm line; alarm equipment.
414 - 19. Before; dry-pipe valve.
414 - 20. Hand.
414 - 21. Damage them and cause leakage.
414 - 22. Wrench handle; locking ring; lift up.
414 - 23. Closed before.
414 - 24. Automatic drip valve; properly seated.
414 - 25. Dry-pipe; wet-pipe; prior.
414 - 26. Automatic fire detectors.
414 - 27. Accelerator; exhauster.
414 - 28. Replaced; compressed.

415 - 1. False. Change "normal" to "abnormally high."
415 - 2. True.
415 - 3. True.
415 - 4. False. Change "at low" to "and."
415 - 5. False. Change "common" to "special."
415 - 6. True.
415 - 7. False. Change "only when two" to "when one."
415 - 8. True.
415 - 9. False. Change "air" to "water."
415 - 10. True.
415 - 11. True.
415 - 12. True.
415 - 13. False. Change "a 10 to 15 psi pressure differential." to "the same pressure reading."
415 - 14. False. Change "OFF" to "ON."

416 - 1. True.
416 - 2. False. In addition to being fixed, the installed systems will also automatically discharge carbon

dioxide while the portable units do not.
416 - 3. False. the CO_2 may be stored as either low-pressure CO_2 at 300 psi at 0° F (requiring refrigerated tanks), or as high-pressure CO_2 at 850 psi at 70° F (in 50-or 100-pound metal cylinders).
416 - 4. True.
416 - 5. False. Automatically operated systems should also have an independent means for manual operation.
416 - 6. True.
416 - 7. False. Handlines may be used to apply CO_2 in any or all of four methods of application discussed.
416 - 8. True.
416 - 9. False. When tripped, the pressure switches close the windows, fire doors, and shut down vent fans in the affected areas.
416 - 10. False. Foam-water systems are a disadvantage when used with electrical equipment due to the corrosive effects of the foam and conductivity of the agent. These systems are an advantage in areas where the hazards involve flammable liquids.
416 - 11. False. Most foam systems use special open-type, combination foam/water deluge sprinker heads.
416 - 12. True.
416 - 13. True.

417 - 1. True.
417 - 2. True.
417 - 3. False. Change "innermost parts" to "vertical and horizontal extremes."
417 - 4. False. Change "gated wye" to "siamese."
417 - 5. False. Change "large" to "small."
417 - 6. True.
417 - 7. False. Change "1 hour" to "30 minutes."

418 - 1. Receiver; battery charger; recorder.
418 - 2. Trouble-signal; pilot lamp.
418 - 3. Vacuum cleaner.
418 - 4. Solid connections; proper support.
418 - 5. Paint; dirt.
418 - 6. Operating test; transmitting; actuating devices.
418 - 7. Meter reading; power unit.
418 - 8. Interrupt the 110-volt ac.
418 - 9. Receiver.
418 - 10. Pure distilled water; acid.
418 - 11. Ammonia; washing-soda solution.
418 - 12. Specific gravity.
418 - 13. Unnecessary force.
418 - 14. Three four-round coded.
418 - 15. Thumbnut; front cover.
418 - 16. Manually move.
418 - 17. Servicing; observing signal recordings.
418 - 18. Register.
418 - 19. Manufacturer's requirements; operational use.

419 - 1. To determine its signaling performance.
419 - 2. Notify all concerned personnel that you will be testing the alarm transmitting equipment.
419 - 3. By operating the manual actuating device connected to the transmitter circuit.
419 - 4. The complete number of alarm-signal rounds for which it is designed.
419 - 5. By using a short piece of insulated wire with alligator clips on each end to shunt (jump) across the remote circuit terminals in the transmitter.
419 - 6. The transmitter should operate for a one-round trouble signal. (This is one way to test for open-circuit fault.)
419 - 7. The result should be either no operation of the transmitter or a one-round trouble signal.
419 - 8. You should restore the transmitter to normal standby condition.

420 - 1. Heated air.
420 - 2. Paint; excessive corrosion.
420 - 3. Test heater device; stop watch.
420 - 4. 120-volt 60-watt; its equivalent.
420 - 5. Marked temperature rating; wattage rating.
420 - 6. Preheat; uniformly; 15 minutes.
420 - 7. Uniform.
420 - 8. Air surrounding the detector.
420 - 9. Explosion-proof; dust-proof.
420 - 10. Hot water; 175° F.
420 - 11. Main water control; 2-inch drain.
420 - 12. Actual placement of the detectors.
420 - 13. Manual alarm boxes.
420 - 14. Thermostatic cable fault locator.
420 - 15. Headphones; exploring head.
420 - 16. Tone; stop; inoperative point.
420 - 17. Swollen; sharply defined twist.
420 - 18. Removed; section spliced in.
420 - 19. Recheck the cable; control unit; normal standby condition.

421 - 1. 1. g.
2. b, c.
3. e.
4. c.
5. a, f.

422 - 1. False. Change "being conducted and turn off the main water control valve." to "being conducted."
422 - 2. True.
422 - 3. False. Change "lower" to "upper."
422 - 4. True.
422 - 5. True.
422 - 6. False. Change "one of the sprinkler heads" to "the inspector's test valve."
422 - 7. False. Change "is not open" to "is open."
422 - 8. False. Change "strainer of the water motor" to "electric circuit or electric bell."
422 - 9. True.
422 - 10. True.
422 - 11. True.
422 - 12. False. Change "that corrects" to "and does not correct."
422 - 13. True.
422 - 14. False. Change "near" to "remote from."
422 - 15. False. Change "water supply" to "piping."
422 - 16. True.
422 - 17. True.
422 - 18. False. Change "24 to 30" to "18."
422 - 19. True.
422 - 20. False. Change "kept in the FULL OPEN position." to "kept approximately one-quarter turn from the FULL OPEN position."

423 - 1. Alarm bypass test valve.
423 - 2. Throttled main water control.
423 - 3. Close; open.
423 - 4. Priming water level test valve; low-point drain.
423 - 5. Dry-pipe valve.
423 - 6. Restriction orifice.
423 - 7. Quick-opening device.
423 - 8. Air and water pressures; temperature.
423 - 9. Loss of air pressure.
423 - 10. Automatic drip valve; intermediate chamber.
423 - 11. Off its seat.

423 - 12. Priming test valve.
423 - 13. Priming test valve.
423 - 14. Quick-opening device.
423 - 15. Loosening the air gage.
423 - 16. Operating screw.

424 - 1. True.
424 - 2. True.
424 - 3. True.
424 - 4. True.
424 - 5. False. Change "is on its seat." to "is off its seat."
424 - 6. False. Change "operative and sealed open." to "operative."
424 - 7. True.
424 - 8. False. Change "three times" to "twice."
424 - 9. False. Change "globe" to "wheel."
424 - 10. Change "open" to "closed."
424 - 11. False. Change "monthly" to "periodically."
424 - 12. True.
424 - 13. True.

425 - 1. Adequate subdivisions.
425 - 2. Flammable vapors; combustible dust.
425 - 3. Automatic sprinkler system.
425 - 4. Draft curtains.
425 - 5. Exterior wall windows.
425 - 6. Narrow slot.
425 - 7. Fusible links; open.
425 - 8. The products of combustion.
425 - 9. Roof monitors; louvers.
425 - 10. Heat release characteristics.
425 - 11. 150 feet.
425 - 12. 3,000; 5,000 (150,000 ÷ 50 = 3,000; 150,000 ÷ 30 = 5,000).
425 - 13. 4; 50,000; 250 (200,000 ÷ 50,000 = 4).
425 - 14. 8; 10.

426 - 1. The extinguisher's expected capability.
426 - 2. Three times as much.
426 - 3. The number indicates the number of square feet of deep-layer flammable liquid fire the extinguisher is expected to extinguish.
426 - 4. By the amount of Class A and B materials used in the construction of the electrical equipment.
426 - 5. The effectiveness of these type extinguishers is usually marked on the label of each extinguisher.
426 - 6. By checking the rating on the label given the extinguisher for the particular class of fire in question.
426 - 7. Class D fire.

427 - 1. Identify; use.
427 - 2. Existing hazards.
427 - 3. Each room.
427 - 4. Light hazard.
427 - 5. Ordinary.
427 - 6. 12; 14.
427 - 7. The number of square feet of area to be protected.; the type hazard involved.
427 - 8. 4,500.
427 - 9. 30 feet.
427 - 10. 75 feet.
427 - 11. 3½ feet.
427 - 12. 40 pounds or less
427 - 13. 32 inches.

CHAPTER 3

428 - 1. True.
428 - 2. True.
428 - 3. True.
428 - 4. False. Change "50 psi" to "a sufficient pressure."
428 - 5. False. Change "should not test" to "should test."
428 - 6. True.
428 - 7. False. Change "in the middle of the three" to "the farthest from the large supply mains."
428 - 8. False. Change "pitot tube" to "pressure gage (Bourdon gage)."
428 - 9. True.
428 - 10. False. Change "of the water flowing out" to "remaining in the system at."
428 - 11. False. Change "hydrants is at least 10 psi" to "hydrants is not greater than 10 psi."
418 - 12. False. Change "AFR 92-1" to "the *Fire Protection Handbook.*"
428 - 13. True.
428 - 14. True.

429 - 1. By providing storage capacities in the supply system.
429 - 2. Elevated storage; ground storage; and emergency reservoirs.
429 - 3. The ground storage system.
429 - 4. By making sure that the pumps have a power supply separate from the normal base power supply.
429 - 5. As distributors.
429 - 6. By laying the system out as a full grid system.
429 - 7. Because of the one-direction flow.
429 - 8. Never less than 8 inches in diameter.
429 - 9. By closing the isolation or shutoff valves to the section of main that is ruptured.
429 - 10. 6 inches.
429 - 11. AFM 88-10, *Water Supply.*
429 - 12. 300 feet.
429 - 13. At least 25 feet away from the building.
429 - 14. The hydrant should be at least 25 feet from any building and at least 6 feet from the paved road surface. Also, it should be no further than 7 feet from an approach with the 4½-inch opening facing the nearest road or approach. Should ditches or other conditions interfere with the above spacing, a maximum of 16 feet is permitted between the hydrant and the closest approach route.
429 - 15. To facilitate day and night identification.
429 - 16. 500 to 1,000.

430 - 1. False. Change "4½-inch pumper connection cap." to "top of the hydrant."
430 - 2. True.
430 - 3. True.
430 - 4. False. Change "nozzle seat." to "drain valve facing or gasket."
430 - 5. True.
430 - 6. False. Change "the nut must be replaced and relubricated." to "then lubricate the packing and thrust collar by oiling the joint between the nut and collar."
430 - 7. False. Change "monthly" to "weekly."
430 - 8. True.
430 - 9. True.

CHAPTER 4

431 - 1. Six.
431 - 2. To detect and correct all fire hazards, some of which could frequently pass unnoticed by all except trained personnel.
431 - 3. To determine if they are properly located and maintained and to correct any fault which would impair the immediate operation of the extinguisher.
431 - 4. So that if a fire does occur, firefighting personnel will be able to move efficiently and safely.
431 - 5. The inspections and corrections must be rigidly enforced.

432 - 1. The nature and complexity of the facility, degree of fire hazard potential, type of operations, and personal habits.
432 - 2. On a weekly to monthly basis.
432 - 3. At least once each year.
432 - 4. Their potential destructiveness.
432 - 5. Target, conflagration, special, and common.
432 - 6. Target.
432 - 7. Common.

433 - 1. Because paper, having a low flashpoint, is extremely susceptible to ignition by a lighted cigarette.
433 - 2. The type of match being used.
433 - 3. The proper safety match has a head that will not fly off when struck and a stick that is treated to eliminate afterglow.
433 - 4. Designated smoking areas, clearly marked and separated from hazardous areas, should be provided.
433 - 5. Smoking area signs and noncombustible disposal receptacles for discarded smoking materials.

434 - 1. When in contact with oils containing spontaneous-ignition characteristics.
434 - 2. A high standard of cleanliness and the complete elimination of loose rubbish from building interiors.
434 - 3. All personnel occupying the building.
434 - 4. The flammable materials should be kept in fire-proof or fire-resistive containers or enclosures.
434 - 5. To prevent the admission of oxygen in the event that sufficient internal heat is generated to cause fire.

435 - 1. Overheating; arcing; sparking.
435 - 2. Overheating.
435 - 3. Sparking.
435 - 4. Standardized; properly maintained.
435 - 5. Use; abuse; age.
435 - 6. Current; amount of voltage.
435 - 7. Maximum capacity (or capacity limitation).

436 - 1. False. Change "close" to "open."
436 - 2. True.
436 - 3. False. Change "thermal" to "electromagnetic."
436 - 4. True.
436 - 5. True.
436 - 6. True.
436 - 7. False. Change "25" to "15."
436 - 8. True.

437 - 1. Rigid conduits.
437 - 2. Safety requirements.
437 - 3. Arcing.
437 - 4. Poor contact; overload of current.
437 - 5. Absolutely necessary.
437 - 6. Lifted over.
437 - 7. Complete replacement.

438 - 1. A spark hazard.
438 - 2. The heat they produce is sufficient to ignite combustibles they come in contact with or close to.
438 - 3. Any substandard lamp is a hazard.
438 - 4. By overcurrent protection.
438 - 5. 25 percent.

439 - 1. By two unlike substances coming in contact with each other.
439 - 2. When in the presence of volatile flammable liquids and/or gases, highly ignitable fibers, and combustible dusts.
439 - 3. By replacing drive belts with chains and gear drives.
439 - 4. All metal parts should be grounded.
439 - 5. Static neutralizers may be installed.
439 - 6. 40 to 50 percent.
439 - 7. By grounding.
439 - 8. By preventing accumulation.

440 - 1. A discharge of atmospheric electricity.
440 - 2. By running a conductor from the uppermost part of the structure down into the ground.
440 - 3. From 10 to 60 inches.
440 - 4. Direct lightning strokes.

441 - 1. Eliminated.
441 - 2. Prevent; impede.
441 - 3. Horizontal.
441 - 4. Contents.
441 - 5. Wooden-shingle roofs; sparks.
441 - 6. Gravitational force; own weight.
441 - 7. Vertical shafts; walls.
441 - 8. Air space insulation.

442 - 1. True.
442 - 2. False. Change "235" to "160."
442 - 3. False. Change "alone is a" to "alone is not a."
442 - 4. True.
442 - 5. False. Change "four" to "three"; and "medium, high, and very high." to "medium, and high."
442 - 6. True.
442 - 7. True.
442 - 8. True.
442 - 9. False. Change "building materials." to "woodwork."
442 - 10. False. Change "28" to "20."

443 - 1. More fire hazards.
443 - 2. Fire extinguishing equipment.
443 - 3. Proper quantity; adequately distributed.
443 - 4. Any level; flammable materials.
443 - 5. Strong; safe; constantly attended.
443 - 6. Underground; segregated; standard safety containers.
443 - 7. Flame; flying embers.
443 - 8. Quick evacuation; any location.

444 - 1. Smoking, matches, and housekeeping.
444 - 2. In self-closing containers.
444 - 3. Large unbroken areas where fire propagation is not impeded.
444 - 4. Type, quantity, location, size, locking, and closing implements of all doors.

445 - 1. Smoking practices, accumulation of rubbish and combustible materials, faulty use and installation of heating facilities, and electrical devices and related parts.
445 - 2. The construction of the warehouse, its location, and type of materials stored.
445 - 3. Large quantities of materials should be dispersed.
445 - 4. By systematically storing the various classes of supplies.
445 - 5. Military and civilian personnel should report any and all regulation violations to the individual in charge as soon as they are noted.
445 - 6. The flat circular ends.

446 - 1. False. Change "Smoking and matches" to "Electrical defects."
446 - 2. False. Change "faulty sprinkler systems." to "insufficient exits."
446 - 3. True.
446 - 4. True.
446 - 5. True.
446 - 6. True.
446 - 7. True.
446 - 8. False. Change "to include" to "with the exception of."
446 - 9. True.
446 - 10. False. Change "nitrate-base" to "acetate-base."

447 - 1. Because of the presence of flammable vapors.
447 - 2. Spark and flame-producing actions and devices.
447 - 3. The fuel expanding due to change in temperature.
447 - 4. The chance of fire spreading to other aircraft is lessened.
447 - 5. 100 feet.
447 - 6. Through the use of nonferrous metals in aircraft structure.
447 - 7. To prevent the accumulation of static electricity which may result from air moving over the aircraft surface.
447 - 8. Vapor and explosion-proof.
447 - 9. Adequate natural or forced ventilation.

448 - 1. Dust explosions; ignition by steampipes.
448 - 2. Construction protection; general housekeeping.
448 - 3. Overheating.
448 - 4. Flammable solvents.
448 - 5. Ventilation.
448 - 6. Heat; drying purposes.
448 - 7. Electrical hazards.
448 - 8. Installation; condition; general environmental factors.
448 - 9. Live sparks.

449 - 1. They must be given priority consideration.
449 - 2. Obtain a medium mesh screen of heat-resisting alloy metal to be placed over the openings.
449 - 3. During periods of low humidity and high winds.
449 - 4. Overheated bearings.
449 - 5. By the frequent elimination of lint and dust and proper removal of all excessive flammable lubricants.
449 - 6. Explosion.
449 - 7. The possibility of their leaking or spilling from their containers.
449 - 8. If they are allowed to come in contact with other acids.
449 - 9. Chlorine.
449 - 10. They emit large quantities of oxygen.
449 - 11. By the sun shining through a bubble or other irregularity in the pane.

CHAPTER 5

450 - 1. All levels.
450 - 2. Training of personnel; functional area.
450 - 3. Easily understand; relate to.
450 - 4. Properly prepared; presented.

451 - 1. True.
451 - 2. True.
451 - 3. True.
451 - 4. False. Change "Specific" to "General"; and "general" to "specific."

452 - 1. 1. c; e.
2. b; h.
3. a.
4. f.
5. d.

453 - 1. Base community relations; off base.
453 - 2. Planning; presenting.
453 - 3. Speaker; assistant; proper uniform.
453 - 4. Designed; adapted; specific audience.
453 - 5. Sponsorship; participation.

454 - 1. True.
454 - 2. False. Change "individual" to "initial group."
454 - 3. False. Change "the commander" to "their."
454 - 4. True.
454 - 5. False. Change "general" to "special"; and "general" to "specific."
454 - 6. True.
454 - 7. False. Change "doing" to "having recurring."
454 - 8. False. Change "after the" to "prior to."
454 - 9. False. Change "Husbands" to "Family sponsors" and "14" to "30."

455 - 1. Available news media.
455 - 2. Office of Information.
455 - 3. Fire chief; fire marshal; each person.
455 - 4. Developing material; selecting the media.
455 - 5. Comparative.
455 - 6. Imperative.
455 - 7. Symbol.
455 - 8. Nominative.

456 - 1. Every group or organization must be included.
456 - 2. Local base competition programs.
456 - 3. A seasonal campaign.
456 - 4. It is a direct attack against a different type fire hazard each month.
456 - 5. National Fire Prevention Week.

457 - 1. They aid immeasurably in the pictorial presentation, and show a professional effort.
457 - 2. The fire protection supervisor.
457 - 3. Base graphics.
457 - 4. Through the use of their skills and equipment.
457 - 5. The film library.

458 - 1. The objective is exactly what you want those attending to comprehend.
458 - 2. Determining the objective (or purpose) of the speech.
458 - 3. As soon as you determine the objective.
458 - 4. Personal knowledge and experience; the knowledge and experience of others; and written information such as books, manuals, regulations, etc.
458 - 5. Outlining your ideas.
458 - 6. It will allow conformity and a logical sequence for the material, and serves as a guide during the speech.
458 - 7. The introduction, body, and conclusion.
458 - 8. The attention step, motivation, and overview.
458 - 9. The body.
458 - 10. To summarize the main points that were covered in the body.

459 - 1. Through proper delivery.
459 - 2. Through skillful use of their voice and body movements.
459 - 3. By distracting mannerisms of the speaker.
459 - 4. Through practice.
459 - 5. They have a hard time looking directly at their audience.
459 - 6. By forgetting yourself and seeking opportunities to speak before others.
459 - 7. An audience can tell if a speaker is sincere. If the audience feels the speaker is, they will believe.
459 - 8. Human characteristics and physical conditions.
459 - 9. When the speaker does not put a great deal of emphasis on preparation.
459 - 10. Notes should be used only when necessary.

460 - 1. False. Change "several" to "two."
460 - 2. True.
460 - 3. True.
460 - 4. False. Change "appliances and must carry a five-man crew." to "appliances."
460 - 5. False. Change "four" to "five."
460 - 6. True.
460 - 7. False. Change "AFR 92-2" to "AFR 92-1."
460 - 8. True.

CHAPTER 6

461 - 1. 1. a, b.
461 - 1. 2. a, d, f.
461 - 1. 3. a, e.

462 - 1. True.
462 - 2. True.
462 - 3. False. Change "most" to "all."
462 - 4. False. Change "cause" to "reason."
462 - 5. False. Change "accidental" to "natural."
462 - 6. True.
462 - 7. True.

463 - 1. Selected; limited.
463 - 2. Base Fire Marshal; Assistant Chief for Techncial Services; fire inspector responsible for the specific building.
463 - 3. Senior fire officer.
463 - 4. Utilities personnel.

464 - 1. True.
464 - 2. False. Change "all cigarette smokers" to "each person."
464 - 3. False. Change "one other team member" to "the group together."
464 - 4. True.
464 - 5. True.

465 - 1. To substantiate findings and opinions.
465 - 2. In case they uncover evidence.
465 - 3. It is sensitive to differences in heat.
465 - 4. By examining the exterior of the building and comparing burn, char, smoke, and heat patterns around doors, windows, and roof.
465 - 5. To determine the extent of fire damage.
465 - 6. The class of fire duration and approximate burn time.
465 - 7. They should be considered as approximations only and not depended upon as being accurate.

466 - 1. The entire interior of the building should be examined.
466 - 2. By examining and comparing the bottom side of tables, shelves, and chairs.
466 - 3. Fire penetration; heaviest fire exposure.
466 - 4. They may actually point to the area of fire origin.
466 - 5. The type of burning, this is, flaming or smoldering.
466 - 6. One section at a time, examining it layer by layer until the floor is reached.
466 - 7. By using burn patterns and corresponding protected areas.
466 - 8. A pattern of deep penetration of one portion of the chair.
466 - 9. The window frame.

467 - 1. False. Change "proof" to "evidence."
467 - 2. True.
467 - 3. False. Change "general" to "exact."
467 - 4. True.
467 - 5. False. Change "clean glass jars." to "sterile, airtight containers."
467 - 6. False. Change "base fire marshal or the base fire chief." to "Security and Law Enforcement or Office of Special Investigations."
467 - 7. True.
467 - 8. False. Change "at least 12 hours." to "as long as necessary."

468 - 1. Facts; conditions.
468 - 2. Working firefighters.
468 - 3. Alarm center operator.
468 - 4. Weather; traffic; general.
468 - 5. Chemicals.
468 - 6. Faint red.
468 - 7. Accelerant.
468 - 8. Their own actions.
468 - 9. Deliberate; purpose.
468 - 10. Unusual; suspicious.

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31C

STOP -

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

57150 03 24

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
FIRE ENGINEERING AND INVESTIGATION

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

320

Multiple Choice

1. (400) The architectural and engineering design of facilities is based upon the

   a. availability of existing utilities.
   b. other facilities in the same area.
   c. actual requirements of the project.
   d. proposed development of the installation.

2. (400) The fire-resistance requirements for facilities vary in accordance with the

   a. construction cost.
   b. occupancy classification.
   c. estimated degree of maintenance.
   d. type of construction and materials chosen.

3. (401) In considering fire partitions in buildings, which of the following would not be a factor in the degree of fire resistance of the partitions?

   a. Type of construction.
   b. Size of the hazardous area.
   c. Severity of the fire hazard.
   d. Type of occupancy.

4. (402) In which category of construction is maintenance not a primary design consideration?

   a. Temporary.
   b. Permanent.
   c. Protective.
   d. Semipermanent.

5. (403) Heavy timber construction should have a minimum fire resistance of how many hours?

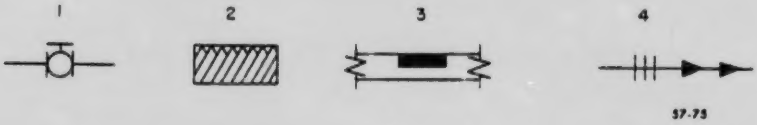
   a. 1.
   b. 2.
   c. 3.
   d. 4.

6. (404) .Design sketches and drawings for display purposes are known as

   a. detail drawings.
   b. general plans.
   c. working plans.
   d. primary drawings.

7. (404) In architectural drawings, any view involving vertical dimensions is called

   a. a floor plan.
   b. a detail plan.
   c. an elevation.
   d. a sectional view.



Volume Review Exercise Figure 1

8. (405) Refer to VRE Figure 1. Of the four symbols shown, the two which are common to the same building trade are

   a. 1 and 2.
   b. 1 and 3.
   c. 2 and 4.
   d. 3 and 4.

9. (405) Refer to VRE Figure 1. How many circuits, if any, are indicated in symbol number 4?

a. 2.
b. 3.
c. 5.
d. Cannot be determined.

10. (405) Refer to VRE Figure 1. Symbol number 1 represents a

a. union.
b. valve.
c. gas outlet.
d. blanked wall outlet.

11. (406) In determining exit criteria, the Life Safety Code is concerned with all the following except

a. the type of occupancy (use) of the facility.
b. the construction of new and existing buildings.
c. what happens to a building after occupants have exited.
d. the type and capacity of exits.

12. (406) The gross square footage of a dormitory 3 stories high, 60 feet wide, and 110 feet long is

a. 19,800.
b. 13,200.
c. 9,900.
d. 6,600.

13. (406) What is the total occupant load of a dormitory 110 feet long, 60 feet wide, and 3 stories high if 200 square feet per person is authorized?

a. 50.
b. 60.
c. 99.
d. 127.

14. (407) The automatic fire detection systems in guest houses and similar buildings are activated by smoke detectors located in which area?

a. Eating.
b. Cooking.
c. Storage.
d. Sleeping.

15. (407) Fire-reporting telephone stations should be located within how many feet of all fixed fueling points?

a. 150.
b. 300.
c. 600.
d. 1000.

16. (408) Automatic sprinkler systems should be installed in service clubs, open messes, and other commercial facilities where areas approximate or exceed how many square feet?

a. 5,000.
b. 10,000.
c. 20,000.
d. 25,000.

17. (408) Normally, which type of automatic fire suppression system is installed in hangar areas?

a. Deluge.
b. Closed-head-dry pipe.
c. Open-head-wet pipe.
d. Closed-head-wet pipe.

18. (409) The three basic types of fire alarms are

a. manual, automatic, and composite.
b. automatic, composite, and transmitter.
c. composite, manual, and transmitter.
d. manual, automatic, and transmitter.

19. (410) What is the primary power source normally used for automatic alarm signal transmitters?

a. Wet-cell batteries.
b. Dry-cell batteries.
c. 110 volts ac.
d. 120 volts dc.

20. (410) Which type of automatic transmitter operates as a result of the rate-of-rise of temperature and is not dependent upon electrical power?

a. Fixed temperature.
b. Rate-of-rise.
c. Pneumatic tubing.
d. Heat-actuated device.

21. (410) The type of heat detector that operates on the photoelectric cell principle is the

a. flame.
b. smoke.
c. combination.
d. thermostatic.

22. (411) What is used to prevent the paper tape from racing if it accidentally breaks on the recorder?

a. A spring motor mechanism.
b. An automatic shutoff.
c. A manual locking device.
d. An automatic locking device.

23. (412) In buildings where automatic sprinklers are installed, records reveal that what percent of all fires were controlled or extinguished by these systems?

a. 66.
b. 76.
c. 86.
d. 96.

24. (412) Sprinkler heads are normally installed in the

a. risers.
b. feeder mains.
c. cross mains.
d. branch lines.

25. (412) The most commonly used sprinkler heads are kept closed by means of a

a. quartz bulb.
b. fusible link.
c. chain link.
d. chemical cup.

26. (413) The alarm valve is located in which section of wet pipe systems.

a. Main riser.
b. Feeder main.
c. Cross main.
d. Branch lines.

27. (413) In a wet-pipe sprinkler system, surges or changes in water pressure may be counteracted by

a. an exhauster.
b. a damper valve.
c. a retarding chamber.
d. a clapper valve.

28. (414) The two types of dry-pipe valves that are currently in use are the

a. pressure and nonpressure.
b. differential and mechanical.
c. electric and hydraulic.
d. exhausted and balanced.

29. (414) The required air pressure for dry-pipe sprinkler system usually ranges between

a. 10 to 15 psi.
b. 15 to 50 psi.
c. 50 to 75 psi.
d. 90 to 110 psi.

30. (415) Which type of sprinkler heads are used in deluge systems?

a. Quartz bulb.
b. Fusible link.
c. Open head.
d. Chemical cup.

31. (415) Automatic operation of the deluge system is normally accomplished by

a. the fusing of one or more of the heads.
b. operation of the spot-type thermostatic cable.
c. triggering of the water flow indication system.
d. operation of one or more heat-actuated devices.

32. (416) The purpose of the delayed discharge device on carbon dioxide fixed systems is to allow

a. time for the window shutters and fire doors to close before discharge starts.
b. the liquid carbon dioxide to flow to the heads ready for discharge when a head fuses.
c. time for personnel to evacuate the area prior to discharge.
d. time for firefighters to don air packs before entering the area.

33. (416) In the foam-water system, heat-actuated devices signal actuation units on which valves to operate the system?

a. Deluge.
b Dry-pipe.
c. Wet-pipe.
d. O.S.&Y./P.I.V.

34. Normally, the type of connection the branch main for a standpipe system has installed for pumper hookup is the

a. siamese.
b. 4 1/2-inch steamer.
c. gated wye.
d. 2 1/2-inch to 1 1/2-inch wye.

35. (418) The battery charger power unit is tested by

a. interrupting the 110-volt ac power supply.
b. insuring the electrolyte is below the top of the plate separators.
c. shunting the banks of batteries with a fault detector.
d. pushing the "press-to-test" reset button.

36. (418) The amount of paper kept on the tape recorder in the alarm center should be enough for at least

a. one trouble signal from each system on the recorder.
b. three four-round coded fire alarm signals.
c. one round from each of the four uncoded signalers on the system.
d. twenty minutes of continuous operation.

37. (419) The automatic transmitter is tested by

a. operating the manual actuating device.
b. using a fault/ground tester.
c. actuating one of the fixed temperature devices.
d. shunting the signaling contacts.

38. (419) When testing for an open-circuit fault, the transmitter should normally

a. sound the local alarm and operate for the complete number of alarm rounds.
b. operate for the complete number of rounds but not sound the local alarm.
c. operate for a one-round trouble signal without sounding the local alarm.
d. sound no alarm signal but the local alarm will sound for one round.

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39. (420) Thermostatic cables are tested

a. by using hot water.
b. with a test heater.
c. by using a cable fault detector.
d. by running your hand over the line.

40. (421) What condition should the sprinkler system testing facilities be in after being restored to normal?

a. Emergency signaling.
b. Manual operating.
c. Automatic signaling.
d. Normal standby.

41. (422) To test the alarm check valve in the wet-pipe system, the first procedure is to

a. drain the retarding chamber.
b. open the O.S.&Y. or P.I.V. valves.
c. open the inspector's test valve.
d. take pressure readings from gages above and below the clapper valve.

42. (422) In a wet-pipe sprinkler system, a clearance of at least how many inches should be maintained below the sprinklers?

a. 12.
b. 18.
c. 24.
d. 36.

43. (423) The drain flow test is made on dry-pipe sprinkler systems in order to

a. get all the water out of the risers and into the feeder mains.
b. allow the air to escape from the system.
c. determine if water supply lines are blocked or restriced.
d. determine if the dry-pipe valve will trip with the control valves open.

44. (423) If the air pressure in a dry-pipe system is above the prescribed limits, it should be reduced to within limits by

a. opening the inspector's test valve.
b. opening the quick opening device.
c. loosening one of the heads to allow air to escape.
d. opening the priming test valve after shutting off the quick opening device.

45. (424) In testing the deluge system alarm equipment, the first step is to

a. shut off the water flow alarm.
b. open the indicator alarm valve.
c. close the main water control valve.
d. activate one of the HADs with a tester.

46. (425) Which type of vent is specifically designed to vent the products of combustion resulting from a fire?

a. Unit-type.
b. Monitor.
c. Continuous gravity.
d. Exterior wall window.

47. (426) The letter found in fire extinguisher ratings and classifications indicates the

a. size of fire it is expected to extinguish.
b. class of fire it is to be used on.
c. type of agent inside the extinguisher.
d. capacity of the extinguisher shell.

48. (427) What kind of fire hazard grading should an auto repair shop be given?

a. Light.
b. Ordinary.
c. Medium.
d. Extra.

49. (427) Which one of the following should be graded as a light fire hazard?

a. Wood working shop.
b. Parking garage.
c. Telephone exchange.
d. Warehouse.

50. (428) What special equipment is used to make a flow test on a water system?

a. Viscosity gage and pitot gage.
b. Pitot gage and 1 1/2-inch outlet cap.
c. Bourdon gage and 2 1/2-inch inlet cap.
d. Bourdon gage and pitot gage.

51. (428) In the formula Q = av used to determine hydrant discharge, "a" represents

a. average amount of flow.
b. average velocity.
c. velocity of moving stream.
d. cross-section area of stream.

52. (429) In which type of water storage system is a pump required to move the water from storage directly into the distribution system?

a. Ground.
b. Elevated.
c. Reserve.
d. Emergency.

53. (429) The most desirable water distribution systems are laid out in

a. a series of dead-end mains.
b. straight lines from a water tower.
c. grid and nongrid patterns.
d. loop and L-shaped patterns.

54. (430) When performing maintenance and inspection on a hydrant, you should use the

a. manufacturer's data.
b. notes from the last inspection.
c. technical order for that hydrant.
d. universal operating instructions.

55. (430) To lubricate the operating nut of a hydrant, you should

a. squirt oil around it.
b. remove the screw in the top of the nut and apply oil, grease, or graphite grease.
c. remove the 4 1/2-inch steamer connection cap and apply grease through the special fitting on the stem.
d. tighten and/or repack the nut collar packing gland with MIL-0-5606 lubricant.

56. (431) Which of the following statements is not one of the purposes of fire inspections?

a. Testing and visual inspection of all fire alarm equipment.
b. Identification of special hazard occupancy areas.
c. Identification of personnel causing a fire hazard to exist in their areas.
d. Monitoring of adequacy and practice of preplanned emergency action.

57. (432) How frequently should the base hospital be inspected by the fire department?

    a. Weekly.
    b. Monthly.
    c. Quarterly.
    d. Annually.

58. (432) A fire hazard in which the destruction of life or valuable property might be involved is known as which type of hazard?

    a. Target.
    b. Conflagration.
    c. Special.
    d. Common.

59. (433) Probably, the greatest single cause of fire is

    a. lightning.
    b. an electrical short.
    c. smoking.
    d. paper.

60. (434) What is the main reason that waste materials such as excelsior and sawdust should be kept in metal containers with self-closing covers?

    a. Oxygen buildup is increased.
    b. These materials are clean waste.
    c. To prevent spontaneous ignition.
    d. These materials have a high flashpoint.

61. (435) The fire hazard potential of electricity can be minimized by

    a. inspecting buildings daily.
    b. having wiring installed in accordance with national electrical codes.
    c. limiting the fuse size in all circuits to 50 amps.
    d. installing wiring in rubber insulated conduits.

62. (436) Which type of device provides the best protection when the circuit overload factor must be held to very close limits?

    a. Plug-type fuse.
    b. Cartridge-type fuse.
    c. Thermal circuit breaker.
    d. Electromagnetic circuit breaker.

63. (436) Thermal circuit breakers are normally used more often than the electromagnetic type because they are

    a. less expensive.
    b. harder to trip.
    c. faster acting.
    d. more sensitive.

64. (437) How should conduit be installed where gasoline vapors are present?

    a. Solid tubing above the vapor line.
    b. Romex wiring, no metal conduit.
    c. Rigid in ceiling only.
    d. Rigid throughout.

65. (437) The chief fire hazard of electrical switches is

    a. sparking.
    b. arcing.
    c. chocking.
    d. overheating.

66. (438) One of the most common hazards found in portable lamps is

    a. low-voltage bulbs.
    b. fragile sockets.
    c. a disconnection release.
    d. lack of overcurrent protection in the switch

67. (439) The accumulation of static electricity can be prevented by

    a. grounding.
    b. using nonfriction rubber hose.
    c. reducing humidity to 60 to 70 percent.
    d. using rubber as an insulator around tanks and nozzles.

68. (440) Lightning rods should extend up to how many feet above a structure?

    a. 3.
    b. 4.
    c. 5.
    d. 2.

69. (440) To minimize the hazards of lightning, the best location for storing explosive powder is

    a. in buildings.
    b. in barrels.
    c. on-top-of-ground storage.
    d. underground storage.

70. (441) The fire inspector checks wooden floors for

    a. trash buildup.
    b. paste wax.
    c. thin flooring or cracks between boards.
    d. openings that will increase the horizontal spread of a fire.

71. (441) Which type of roof is considered the greatest single contributing factor to conflagrations?

    a. Wooden-shingle.
    b. Tar and stone.
    c. Aluminum covered.
    d. Asbestos-tar shingle.

72. (442) For a proper margin of safety, heating devices should be installed so that exposed woodwork will not be heated in excess of

    a. 160° F.
    b. 180° F.
    c. 200° F.
    d. 210° F.

73. (442) Heating devices are rated as low, medium, or high according to

    a. the size of the area being heated.
    b. the temperature capability of the device.
    c. British thermal units.
    d. the fuel consumption capability of the device.

74. (443) In comparison to completed buildings, fire hazards in buildings under construction are usually

    a. more.
    b. less.
    c. the same.
    d. negligible.

75. (444) Approximately 60 percent of all fires at night occur in

    a. mess facilities.
    b. administrative buildings.
    c. barracks.
    d. warehouses.

76. (445) When it becomes necessary to store drums of engine fuel in open areas, the drums should be stacked

    a. on end in small groups.
    b. in low areas so the vapors will not spread.
    c. on end in large groups away from other combustibles.
    d. on their sides because the ends are the weakest points.

77. (446) Approximately half of the fires that occur in theaters originate in the

a. furnace room.
b. dressing room.
c. projection booth.
d. auditorium.

78. (446) What is the most frequent cause of fires in hospitals?

a. Sparks on the roof.
b. Electrical defects.
c. Smoking and matches.
d. Spontaneous ignition.

79. (447) What type of fire extinguisher is recommended for standby use when starting an aircraft engine?

a. Foam.
b. Water.
c. Dry powder.
d. Carbon dioxide.

80. (448) The best way to prevent vapor ignition in a paint spray shop is to

a. ventilate properly.
b. use water spray.
c. practice good housekeeping.
d. have vapor proof lights installed.

81. (449) The chief hazard concerning acids is

a. flammability.
b. leakage.
c. toxic vapors.
d. corrosiveness.

82. (449) Which of the following is not a hazard associated with chlorine?

a. Flammability.
b. Reaction with turpentine.
c. Explosion when in contact with ammonia.
d. Poisonous gas.

83. (450) A successful fire prevention program can best be achieved by the

a. training of a highly efficient fire prevention unit.
b. installation of adequate alarm and sprinkler systems at key locations.
c. development of a program that would result in a well-informed and highly motivated base population.
d. assignment of sufficient fire protection personnel to support a thorough inspection program.

84. (451) When developing a fire prevention educational program, what should be determined first?

a. The number of people to be educated.
b. The place to hold the meeting.
c. The cost of the program.
d. A specific set of goals.

85. (451) What type of fire prevention program should be presented to the base population as a whole?

a. Lecture.
b. General.
c. Specific.
d. Discussion.

86. (452) One of the most successful methods of reinforcing the interest in fire prevention for nonfirefighting personnel is to have

a. regular meetings with the building fire wardens.
b. informal visits with all base personnel.
c. friendly and polite discussions during your fire prevention inspections.
d. special fire prevention programs.

87. (454) Who is responsible for fire prevention instruction for military housing occupants?

    a. Auxiliary firefighters.
    b. Base fire department.
    c. Off-duty firefighters.
    d. Military sponsor.

88. (454) Training in fire prevention and safety procedures is conducted for selected functional areas

    a. on an individual basis.
    b. on a monthly basis.
    c. by a general program.
    d. by special programs for the specific hazards of the area involved.

89. (455) Which of the following is not a form of advertising for fire prevention programs?

    a. Nominative.
    b. Imperative.
    c. Directive.
    d. Comparative.

90. (456) For local base fire prevention competition, what may be awarded by the fire department?

    a. Monetary awards.
    b. Three-day passes.
    c. Trophy or plaque.
    d. Presidential letter of appreciation.

91. (456) Ideas for promotional programs for National Fire Prevention Week may be obtained from the

    a. Federal Academy for Fire Protection.
    b. National Fire Prevention Center.
    c. National Fire Protection Association.
    d. Federal Fire Prevention Advertising Center.

92. (457) All of the following agencies are generally sources of assistance in developing fire prevention educational programs except

    a. Base graphics.
    b. Base photo laboratory.
    c. Film library.
    d. Base education office.

93. (458) In developing a speech on fire prevention, the first step is to

    a. consider the objective.
    b. research the topic.
    c. check appropriate regulations and manuals.
    d. gather written material.

94. (458) Normally, the best source of information to use for primary research in speech preparation is

    a. the film library.
    b. the base library.
    c. personal knowledge.
    d. the experience of others.

95. (459) The main purpose of using voice and body language during a speech is to

    a. cover the subject.
    b. keep the audience motivated.
    c. project ideas and accomplish the objective.
    d. keep the audience entertained.

96. (459) When giving a speech, notes should be used

a. all of the time.
b. most of the time.
c. only as needed.
d. only when the speaker forgets the material.

97. (460) An Air Force base needs a mutual aid agreement with surrounding communities to

a. provide the civilian fire departments training with Air Force equipment.
b. provide Air Force fire departments enough personnel and equipment to meet the demands of major fires.
c. reduce the cost to the Air Force.
d. replace Air Force firefighting equipment.

98. (460) Normally, civilian fire departments have how many minutes to respond to an Air Force base mutual aid request?

a. 10.
b. 20.
c. 30.
d. 60.

99. (461) Fires that must be investigated are

a. those that have caused loss of life.
b. those with property damage of $50,000 or more.
c. those with property loss of $25,000 or more.
d. all fires on base.

100. (461) A damage value of what amount must be exceeded before a technical investigation will be made by local Commanders?

a. $1.
b. $25,000.
c. $30,000.
d. $50,000.

101. (462) The term "cause" of a fire means that which

a. made the fire propagate.
b. extinguished the fire.
c. led to the causes of a fire.
d. made the fire start.

102. (462) Which of the following is not a general class of fire cause?

a. Natural.
b. Artificial.
c. Accidental.
d. Arson.

103. (463) One of the persons who normally provides technical experience for an investigation is the

a. firefighter on lead handline.
b. firefighter making rescue.
c. Assistant Chief of Operations.
d. Assistant Chief for Technical Services.

104. (464) At a fire investigation scene, personnel should be cautioned against

a. smoking.
b. drinking.
c. using a knife to probe.
d. wearing protective clothing.

105. (465) When examining the exterior at a fire scene, an unusual burn pattern indicates

a. the depth of wood char.
b. how long the fire was burning.
c. the use of flammable liquids.
d. the direction of the wind.

106. (466) At what temperature do light bulbs begin to swell and lose their shape?

a. 800° F.
b. 900° F.
c. 1,000° F.
d. 1,200° F.

107. (466) When examining walls within a room, what should be observed if fire was present?

a. Fire patterns or fire cones.
b. The color of the walls.
c. The number of open windows.
d. Whether or not pictures were on the wall.

108. (467) Physical evidence found at a fire scene should be

a. photographed immediately.
b. photographed outside in good light.
c. put in cardboard boxes for safekeeping.
d. taken to the security police office.

109. (468) What information can the alarm operator usually give the fire investigator?

a. Nature of the alarm.
b. The color of the flame.
c. Density of smoke.
d. Construction of the building.

110. (468) What is probably burning if brown smoke is coming from a burning building?

a. Sulphur.
b. Wood.
c. Petroleum products.
d. Chemicals.

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FIRE PROTECTION SPECIALIST

(AFSC 57150)

Volume 4

First Aid and Rescue

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

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Preface

WHICH COMES first, the first aid or the rescue? No one can give you a straight answer to this question. The governing factors will be the physical situation, nature, and degree of injuries. In some cases, you may need to move an injured person to a safe area before you start first aid. Then again, you may have to start first aid before you move the individual. YOU will have to determine what is to be done first and then take action.

In the first chapter of this volume, we will discuss various areas of first aid. After our discussion of first aid itself, we will deal with transporting the injured. In the last chapter, we will cover forcible entry and rescue.

Please note that in this volume we are using the singular pronoun *he, his,* and *him* in its generic sense, not its masculine sense. The word to which it refers is person.

Code numbers appearing on figures are for preparing agency identification only.

If you have questions on the accuracy of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTGOX, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

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This volume is valued at 24 hours (8 points).

Material in this volume is technically accurate, adequate, and current as of July 1979.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its test.

Emergency First Aid

AS A FIREFIGHTER, you are expected to have a better understanding and knowledge of first aid than most other airmen. The need for this knowledge is twofold. First of all, you will need to give first aid to fellow firefighters injured during the performance of their duties. Secondly, you must aid the general public when the need arises.

As a good first-aider, you must deal with the whole situation—the individual as well as the injury. When giving first aid, a person who lacks sufficient knowledge could possibly cause even further injury to an injured person. A person causing such injuries may be held liable in a court of law. Anyone attempting to assist another must use care and skill in performing first aid.

In practicing first aid, it is just as important to know what not to do as it is to know what to do. Keep calm, use proven first aid measures, and seek medical help as soon as possible. Never attempt treatment that is beyond your skill, and never move an injured person unless absolutely necessary.

Your job is to take proper emergency measures and to have the patient in better condition for treatment when trained medical assistance becomes available.

1-1. Life Saving Steps

As you know, first aid is the immediate and temporary care given the victim of an accident or sudden illness until the services of trained medical personnel can be obtained. What you do will depend upon the nature of the injuries and condition of the patient/victim. The two most important things to do are to maintain an airway and control severe bleeding.

600. State the causes and results of asphyxiation.

Many unconscious patients do not require artificial ventilation but merely require proper positioning of the head to allow adequate natural breathing through an open air passage. A good example is the patient with a head injury whose fate often lies in the hands of the first-aider. His brain may suffer irreparable damage in a few minutes if he is not provided with adequate means of breathing. The first-aider, when confronted with an unconscious and nonbreathing patient, should make every effort to restore breathing at the scene of the accident before rushing the patient to the hospital.

Importance of Prompt Action. Life is sustained by a close relationship between the heart, lungs, and brain. The heart pumps blood to the lungs, where the blood picks up oxygen. The oxygen-enriched blood is returned to the heart, from which it is pumped to the brain and other parts of the body. In the brain, it nourishes the cells that regulate every body function. As long as the brain cells receive proper nourishment, the brain will send signals to the heart and lungs to regulate their activity. This cycle continues automatically without interruption throughout the human life span.

If, for some reason, the air supply to the lungs is restricted or stopped, the cycle is interrupted, the brain does not get enough oxygen to survive, and the signals that regulate heart and lung activity slow down and stop. As the action of the brain, heart, and lungs cease, so does life itself. This condition is known as asphyxia. The speed with which asphyxiation takes place depends a great deal upon the degree of airway obstruction. When the obstruction is complete, the brain cells cease to function in about 4 to 6 minutes, and heart action stops a few minutes later. A partial obstruction initiates a slower process of damage to the brain. The most obvious cause of airway obstruction is, of course, the accumulation of foreign objects in the airway. An equally dangerous but less obvious cause of airway obstruction is a state of unconsciousness. During unconsciousness, regardless of the cause, the muscles that control the lower jaw and tongue relax. This usually leads to an obstruction in the pharnyx when the patient's neck is bent forward. (See fig. 1-1.) Flexion of the neck causes the lower jaw to sag; and, since the tongue is attached to the lower jaw, it drops against the back of the pharynx and over the larynx. This causes a blockage. (See fig. 1-2.) A person who is under the influence of alcohol or drugs may develop an airway obstruction from nothing more than lying on a bed with a pillow under his head in such a manner as to cause the neck to be flexed. In a normal situation, automatic reflexes would cause a person to turn over

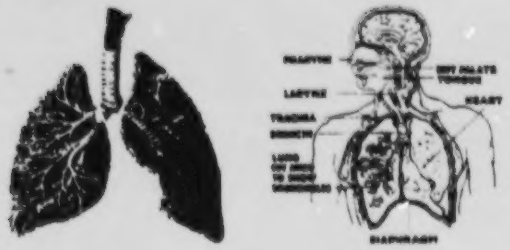

Figure 1-1. The respiratory tract.

in bed when the tongue falls back into the throat. Due to the depressed state of the nervous system in the alcohol or drug user, however, there may be no automatic and involuntary reaction to airway blockage.

Although a flexed neck and foreign matter in the air passage are the most common forms of airway obstruction, there are occasionally other blockage sites. When the nasal passage is blocked by congestion or mucus, closure of the lips and teeth may also cause a blockage. The first-aider should know how to make an immediate survey of further possible causes of obstruction in order to take the proper corrective action.

Exercises (600):

1. What happens to a patient who is not provided with an adequate means of breathing?

2. The heart and lungs receive signals to regulate their activity from the ________

3. What happens when the supply of air to the lungs is restricted or stopped?

4. What governs the speed of asphyxiation?

5. About how long does it take for the brain cells to stop functioning when there is a complete obstruction of the airway?

6. How may unconsciousness cause a blockage of the airway?

7. In normal situations, what causes a person to turn over in bed when his tongue blocks the airway?

8. What are the most common forms of airway obstruction?

601. State how to recognize airway obstructions.

Recognition of Airway Obstructions. A "rule of thumb" that may be used to great advantage in surveying patients for airway obstruction is to tilt the patient's head backward and do the following:

- LOOK for breathing movements.
- LISTEN for airflow to the mouth and nose.
- FEEL for air exchange.

It is easy to be misled into thinking a patient is breathing adequately by simply observing that the chest is rising and falling in a normal manner. As a matter of fact, involuntary muscular action may cause continued chest movement even though there is a complete obstruction. Looking for breathing movements should be only the first of three steps in determining a patient's respiratory condition.

You should not assume that a patient is breathing adequately unless you can hear and feel an exchange of air through the mouth and/or nose. To make this determination, you should place your ear close to the patient's mouth and nose to hear and feel the exchange

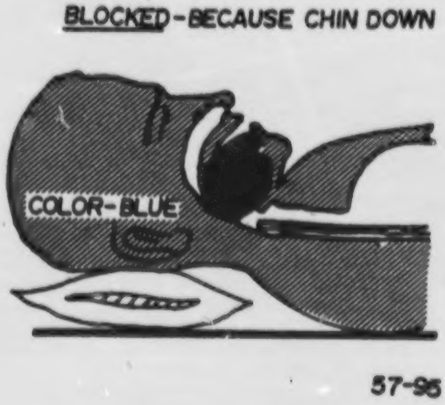

Figure 1-2. Blockage caused by the tongue.

of air. In cases of complete obstruction, there will be no detectable movement of air. Cases of partial obstruction are easier to detect and may be identified by listening. Noisy breathing is a sign of partial blockage of the air passages. For example, "snoring" usually indicates air passage obstruction by the tongue that can be caused by a flexed neck. Spasms of the larynx are indicated by "crowing", and a "gurgling" sound indicates foreign matter in the windpipe. Under no circumstances should a "noisy" breathing condition go untreated.

A dependable sign that the brain is getting too little oxygen is cyanosis. This condition is characterized by a noticeable blue or gray color in the tongue, lips, nail beds, and skin. In patients with dark skins, the blue or gray color may be a reliable sign in the mouth, mucous membrane, or inner surface of the lips and eyelids.

Exercises (601):

1. What should you do when surveying a patient for airway obstructions after you tilt his head back?

2. What action on the patient's part may mislead you into thinking he is breathing in a normal manner?

3. Besides watching for movement, how should you determine if the patient is breathing adequately?

4. What is the easiest way of detecting a partial obstruction of the airway?

5. "Snoring" usually indicates obstruction of the airway by the ________

6. Foreign matter in the windpipe is indicated by a ________ sound.

7. How is cyanosis characterized?

602. Specify how to open an obstructed airway.

The first-aider should learn to recognize air passage obstructions immediately and act within seconds, using the following steps until the obstruction is corrected. If any step opens the airway, it is not necessary to go any further, but only to assure that the patient breathes properly and continues to do so.

Step 1. Quick Cleaning of the Victim's Mouth. Using your finger, quickly sweep the patient's mouth clear of foreign objects, broken teeth or dentures, sand or dirt, etc., as shown in figure 1-3.

Step 2. Tilting the Head Back. Place the patient on his back with his face up. Tilt his head backward as far as possible so that the front of his neck is stretched tightly. If necessary, his shoulders can be elevated with a blanket roll to keep the head in a tilted-back position. If he is not breathing, the first-aider should not be concerned with the possibility of a broken neck, since treatment of airway obstructions has priority over all other emergency first aid. (NOTE: Never put a pillow, rolled blanket, or other object under the patient's head. This defeats the purpose of the head tilt by flexing the neck and perhaps blocking the passage even more.)

This step accomplishes the following three things simultaneously: (1) it places the patient's airway in the best possible position for spontaneous breathing if the breathing processes have not stopped altogether; (2) it allows the first-aider to make an immediate determination of the patient's condition by the look, listen, and feel method described earlier and by observation of his coloration; and (3) it positions the patient properly for artificial ventilation if he is not breathing and if the head tilt does not start spontaneous breathing.

If the unconscious patient cannot be placed on his back, which might be the case in an aircraft, car, boat, or bus, he should be supported in an upright position with his head bent backwards and his face tilted up as if looking toward the sky. Forcing air into his lungs while he is in this position is quite possible.

While it seems a likely means of providing a good airway, the prone position with the face down and chin forward is ineffective for the nonbreathing patient for the following reasons:

- The first-aider has a great deal of difficulty in holding the head tilted back and the jaw forward to keep the passage open.
- The patient's face is concealed so that the first-aider cannot watch the color of the tongue and lips, nor can the throat be cleared if necessary.
- Effective ventilation is almost impossible.

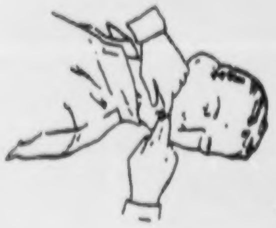

Figure 1-3. Cleaning out obstructions.

- When recovery begins, natural breathing is difficult in the face down position, because a good part of the body weight has to be lifted each time the patient breathes.

If tilting the head back opens the airway and the patient starts to breathe spontaneously, go no further. Otherwise, go on to step 3.

Step 3. Forcing Air Into the Lungs. If the head tilt alone does not succeed in opening the airway, try to force two or three good-size breaths quickly into the patient's lungs through the mouth while holding the nostrils pinched shut. (See fig. 1-4.) This forced ventilation may in itself be enough to start spontaneous breathing, or it may overcome partial obstruction that has restricted the breathing. Watch the chest of the patient to ascertain that air is reaching his lungs.

If the patient's chest rises and falls with two or three quick ventilations, the airway is unobstructed. If forcing the air into the patient's mouth does not open the airway, it is necessary to take the actions listed in steps 4 and 5.

Step 4. Lifting the Jaw. If both tilting the head and positive ventilation have failed to get air into the patient's lungs, it may be necessary to accentuate the stretch of the neck to get the tongue out of the way. One of the two jaw-lift methods can be used.

To pull the tongue as far as possible, place your fingers under the chin, and pull the jaw forward. (See fig. 1-5.) If it is not possible to insert your thumb in the patient's mouth because it is clenched, try the two-hand jaw-lift method. (See fig. 1-6.) Grasp the angles of the patient's jaw, pull with both hands just below the ear lobes, and lift the jaw forcibly upward so that the teeth on the lower jaw are in front of the teeth on the upper jaw. Make sure that you do not flex the head forward when attempting to pull the jaw forward.

The tongue is now in the most extreme forward position and it is unlikely that it is blocking the passage. Another quick breath into the patient's mouth will determine whether or not the airway exists and is clear. If the airway is still closed, go on to step 5.

Step 5. Clearing the Air Passage. When attempts to establish an open airway by head lift, forced ventilation, and maximum jaw extension all fail, there is probably a foreign object lodged so deep in the patient's throat that the quick sweep of your fingers through the mouth in step 1 failed to reach it. Try to reach the object with your extended index finger. If this fails, attempt to dislodge the object by concussion. Turn the patient on his side and administer a few sharp slaps to the back between the shoulders. Once again, sweep your fingers inside the patient's mouth to see if the object has been dislodged.

If the patient is a child or infant, hold him upside down and give him a few sharp pats between the shoulders. This should dislodge the object without difficulty.

REMEMBER: If the patient is in a desperate state of oxygen shortage, do not waste time trying to clear the foreign matter from the air passage. Forcing air into the lungs is more important and often succeeds despite some blockage. Speed is of the essence. If it is obvious that efforts to open the airway will not be immediately successful, transport the patient to a medical facility without delay. Surgical procedures will most likely be needed to save his life.

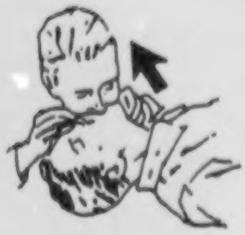

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Figure 1-4. Forced ventilation.

Exercises (602):

1. What is used to clear foreign matter from a patient's mouth?

2. What priority does treatment of airway obstructions have?

3. Why should objects never be placed under a patient's head?

4. How is an unconscious patient treated for an obstructed airway?

5. What should you do if the head tilt alone doesn't open the airway?

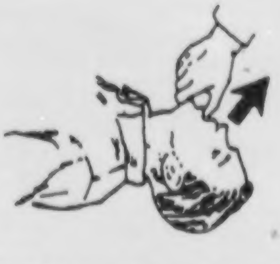

Figure 1-5. Jaw lift--thumb method.

6. If a patient's chest rises and falls after two or three quick ventilations, what is indicated?

7. How do you accentuate the stretch of the neck to get the tongue out of the way?

8. Describe how to lift the jaw using the two-hand method.

9. What is the probable cause of obstruction when the head lift, forced ventilation, and maximum jaw extension have failed to establish an open airway?

10. Explain how to dislodge a deep set object in the throat of an adult.

11. How should you dislodge an object in the throat of an infant?

603. State the work capacity of the human heart and signs of abnormality in the circulatory system.

The Heart. The heart weighs less than a pound, is the size of a fist, and has scant resemblance to the simple arrow-pierced emblem carved on trees. It pumps all of the body's blood content through its chambers every minute, beats throughout life, grows from less than an ounce at birth, starts work months before that, and continues to beat thereafter. In short, the heart is a formidable pump. In fact, it is two pumps, each having similar output. One sends the blood through the pulmonary network, and the other sends it through the body or systemic network. Each pump produces 2,000 gallons a day, or 50 million gallons in a lifetime. Considering its continuous labor and responsibility, it does seem entirely reasonable that failure of the heart and its blood vessels is the major cause of death in this country. Figure 1-7 shows the heart. You can follow the flow of the blood through it.

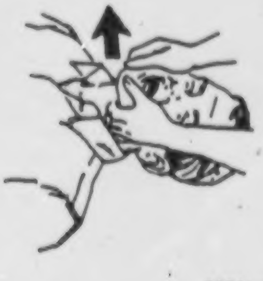

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Figure 1-6. Jaw lift—two-handed method.

Venous blood returning to the heart first enters the right auricle (named after its alleged resemblance to a little ear). It is then pumped by this auricle into the right ventricle (the name means a little stomach). This ventricle pumps the blood around the lungs, and the blood flows back from the lungs into the left auricle. This third chamber pumps it into the most powerful chamber of all, the left ventricle. It leaves this ventricle through the aorta, a vessel an inch in diameter, which receives the heart's output of one-fifth of a pint in every beat. In mechanical terms, this means the continuous exertion of between 35 and 50 foot-pounds of pressure every minute and the exceptional exertion of 500 foot-pounds or more during strenuous exercise.

The heart is a very efficient pump and must do its work without interruption. Certain factors, however, can affect the heart pumping rate. For example, a sudden emotional reaction may increase the rate, and a blow to the abdomen will slow it down. To prevent high or low blood pressure, there are nerve receptors which tell the brain to signal the heart to either speed up or slow down.

The pulse is usually full, bounding and racing in states of fright. In the early stages of hemorrhage and in states of shock, it is thin already, weak, or rapid. In cases of severe injury or illness, it may be very irregular or even imperceptible.

To take a pulse reading, you should choose an artery close to the surface and close to the heart. It is generally felt that the most dependable places or locations for taking a pulse reading are the carotid artery in the neck and the femoral artery in the thigh. Always take the reading with your first two fingers and never with your thumb, because the thumb has a pulse of its own.

When increased demands are being made upon the heart and its beat quickens, it also pumps more with each beat. Many machines become less efficient as they go faster, but the heart's output—it's stroke volume—can be nearly doubled from the normal resting output. Consequently, with both more breaths and more blood per beat, the heart can pump five times the quantity of blood than it normally pumps when at rest. Due to this tremendous output of the heart, the first-aider must be prepared to take prompt and positive action to control the flow of blood when it is being lost to the outside of the body.

Heartbeat. The human heart beats roughly 70 times a minute for the average adult, or four times for every breath. It will, therefore have beaten 2.5 billion times before it finally calls it a day at the end of an average life. Each individual slows down his or her heart as he or she grows; the human infant has a pulse of about

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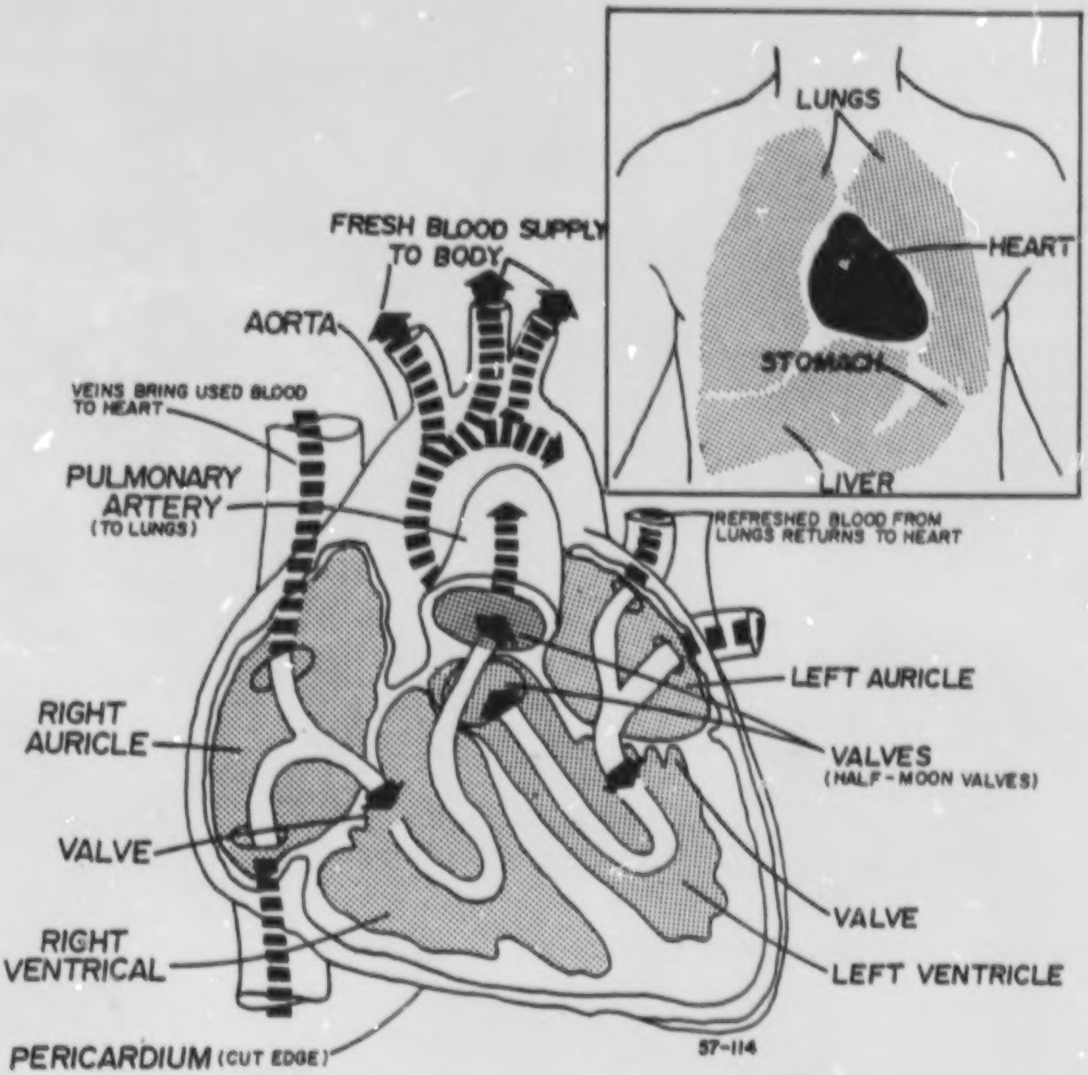

LUNGS
HEART
STOMACH
LIVER
FRESH BLOOD SUPPLY TO BODY
AORTA
VEINS BRING USED BLOOD TO HEART
PULMONARY ARTERY (TO LUNGS)
REFRESHED BLOOD FROM LUNGS RETURNS TO HEART
LEFT AURICLE
RIGHT AURICLE
VALVES (HALF-MOON VALVES)
VALVE
VALVE
RIGHT VENTRICAL
LEFT VENTRICLE
PERICARDIUM (CUT EDGE)
57-114

Figure 1-7. The human heart.

130, which will slow down to the adult rate of about 70. Before birth, the heartbeat is even faster. These extreme speeds are matched again only during strenuous exercise or anxiety or both, when the pulse rate may triple its customary pace.

As you can see, the rate of the heartbeat is not a dependable sign in itself. For instance, a person who is in poor physical condition will have a faster heartbeat after limited exercise or perhaps no exercise at all than the athlete who has a normal beat of only 40 or 50 per minute. In emergency care, the change in the heartbeat rate is much more important than a one-time reading. The first-aider should take a pulse reading every 2 or 3 minutes to note any difference in the rate. An increase in the rate can indicate bleeding, shock, or a number of other conditions.

Exercises (603):

1. What percent of the body's blood content is pumped through the heart's chambers every minute?

2. Which chamber of the heart is the most powerful?

3. What is the diameter of the aorta?

4. When would you expect to find a pulse that is thin, thready, weak, or rapid?

5. What are the most dependable locations for taking a pulse?

6. About how many times does the heart beat every minute for the average adult?

7. Why is the rate of the heartbeat in itself not a very dependable sign?

8. How often should you take a victim's pulse?

9. An increase in a victim's rate of heartbeat will indicate what?

604. Identify causes and results of severe blood loss.

For you to realize the extreme danger involved when a person is losing blood, you must know the vital services that blood provides to the body.

Blood, Corpuscles, and Platelets. The transport medium of the body is blood, the principle fluid of the circulatory system. Slightly heavier than water, three times as viscous, half plasma and half corpuscles, human blood is pushed around the body once every minute even under quiet conditions. It is squirted out of the heart, falls back to the valves, is squeezed through the capillaries, and then is sucked and forced along the veins to start the whole cycle once more. During its stormy circulation, it carries water, takes carbon dioxide to the lungs, and oxygen from them. It carries nutrients to the cells and waste products from them, transports heat from the hotter to the cooler regions, and distributes hormones. The blood is also a circulator of antibodies, the anti-infection agents, and of its own white cells. It carries its own self-sealing mechanism for occasions when its essential fluidity has to be congealed to block an open wound.

The average human body, weighing 156 pounds, contains 12 pints of blood, or a pint for every 13 pounds. Blood weight is about one-twelfth of total body weight. Although one pint can be given in a transfusion with no effect on the body, the loss of blood from, for instance, a wound can never be regarded casually. Though the body has proved itself capable of losing at least one-quarter, possibly one-third, of its vital transport fluid without any necessarily severe physiological consequences, the loss of half is likely to be fatal. Transfusion must intervene to prevent death in such cases.

Loss of 2 pints in the adult male will result in a moderate state of shock. Loss of 4 pints (30 percent) will result in a severe state of shock that places the body in extreme danger. NOTE: When a large blood vessel has been cut, death may result in less than 1 minute.

When an abnormal loss of blood from the circulatory system occurs, there are several effects on the body: (1) the body and system suffers from a lack of oxygen, (2) there is a loss of blood pressure due to the loss of blood volume, (3) the heart increases its pumping rate to compensate for the reduced blood pressure, and (4) the force of the heartbeat is reduced since there is less blood to pump. When the bleeding is unchecked, this cycle quickens, and the body plunges deeper into shock. Remember, blood loss must be controlled at once.

When bleeding occurs internally, there is not a great deal you can do for the patient except to treat for shock. The patient must be transported immediately to a medical facility.

The Blood Flow. So far as the heart is concerned, blood distribution is an elementary business. It pumps it all into the aorta, and that is that. At a customary speed of 15 inches a second, the blood is received by the aorta, from which the branches almost immediately begin to distribute it around the body. With all this spreading out, the speed slackens, mainly because the cross-sectional area of all the arterioles and then of the capillaries is so much greater than that of the inch-thick aorta. Within a capillary, the blood flow is only about 1/50 of an inch per second.

The heart can boost its delivery of blood almost fivefold if need be. From a gallon a minute, it can rise to 5½ gallons a minute at times of maximum output.

You can see that bleeding is easier to control if the patient is in a relaxed state than it would be if he were agitated. It is important to remember that the speed at which blood is flowing is a determining factor in the amount of blood lost from a severed vessel. It is also a determining factor in poisoning and certain types of shock which will be discussed in a later section.

Exercises (604):

1. Under quiet conditions, how long does it take for the blood to circulate through the body?

2. The average human body contains how many pints of blood?

3. A state of severe shock will result when an adult male loses how much blood?

4. What is the maximum output of the heart?

5. Why is bleeding easier to control when a patient is relaxed?

6. What is the determining factor in the amount of blood lost from a severed vessel?

605. Name the methods for controlling bleeding and verbally locate pressure points.

Methods of Control. The stoppage of bleeding is one of the most important forms of emergency first aid. We have just seen that the body may be emptied very quickly of its life-giving blood without prompt action by the first-aider. The victim will die unless bleeding is stopped just as surely as he will without an open airway. If the situation should arise that both asphyxiation and bleeding is occurring at the same time, try to control both at the same time. If you cannot control both at the same time, first give your attention to the condition to the situation which appears to pose the more immediate threat to life.

There are several ways to control bleeding, but for the first-aider there are basically two methods: (1) the pressure methods (direct and digital), and (2) the tourniquet method.

Direct pressure. The most effective method of controlling bleeding is the direct pressure method. Even with severed arteries and veins, this method will usually stop the bleeding. To use the direct pressure method, the first-aider merely applies pressure directly to the wound. (See fig. 1-8.) This should be done with a sterile dressing, and the dressing should not be removed. If this dressing should become saturated with blood, apply another one directly over the first.

This method usually will not completely shut off the flow of blood, but it will slow it down to where normal coagulation (blood clotting) will take place. When the dressing is in place, hold it firmly over the wound WITHOUT RELEASING IT, or secure it in place with a pressure bandage.

When a limb is amputated in a traumatic (injury) situation, it is called a "traumatic amputation". The mechanism of the injury (the cause) will determine the amount of bleeding which occurs. If the amputation is smooth, there will be very little bleeding, and it usually can be controlled by a pressure dressing over the stub. If the amputation is a jagged tear, bleeding may be profuse and may require another type of control.

When an artery is cut smoothly, it has a natural tendency to collapse and seal itself off; but if it is torn jaggedly lengthwise, it will require assistance. If bleed-

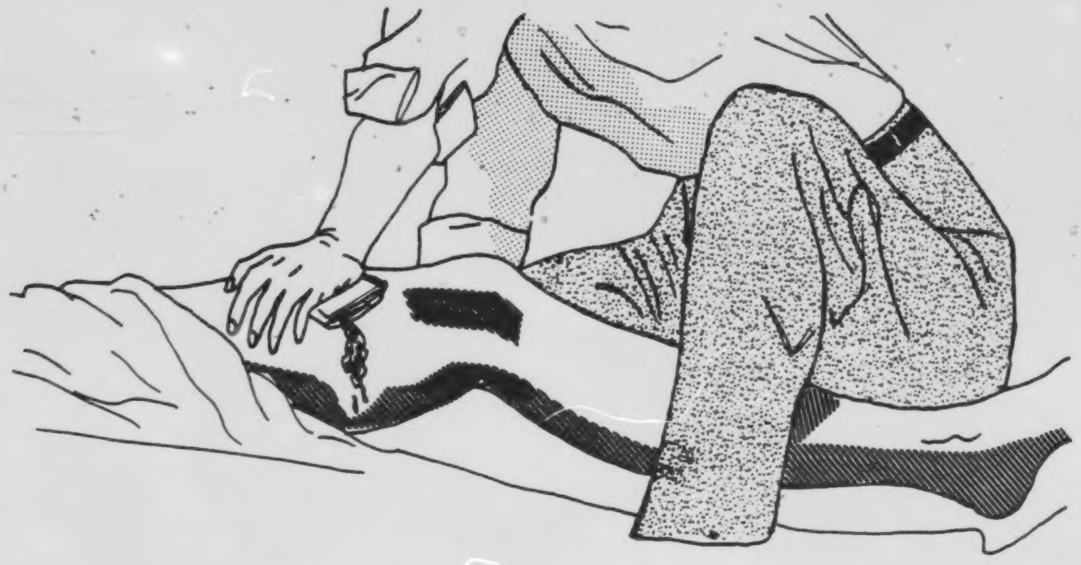


Figure 1-8. Direct pressure.

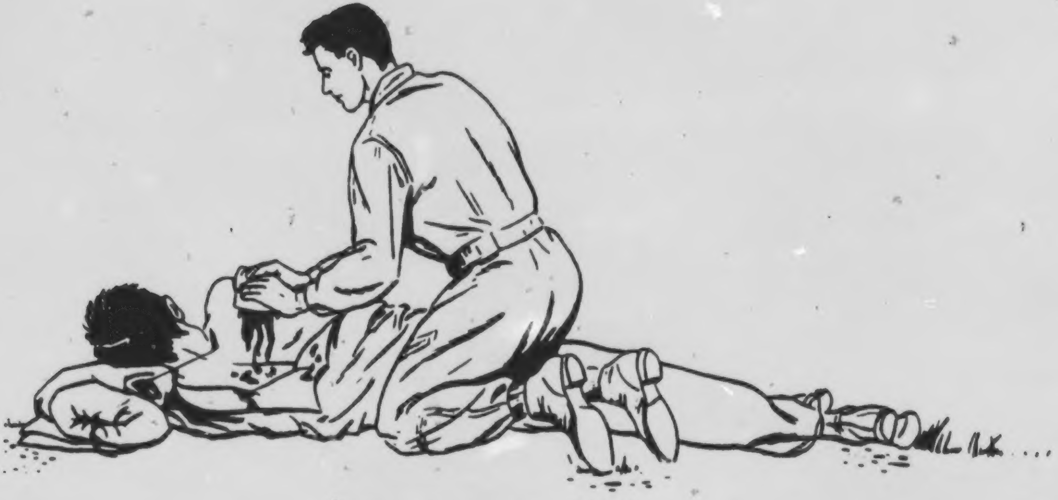


Figure 1-9. Direct pressure—finger insertion.

ing is profuse and direct pressure on the top of the wound is not effective, the first-aider may extend his fingers directly into the wound and compress the bleeding vessel (fig. 1-9).

Remember, direct pressure is the most effective method of controlling bleeding and should be attempted first. This is accomplished by direct pressure on top of the wound, a pressure dressing and bandage, extending the fingers directly into the wound to compress the bleeding vessel, and any other method used where the entire arterial blood is not cut off.

In the event that the bleeding cannot be controlled by the direct pressure method, there is another method which will be more effective if properly applied. This method is called the digital pressure method, commonly called pressure point.

Digital pressure. Digital pressure is applied directly to an artery with the fingers or hand. Special places at which digital pressure can be applied effectively are known as pressure points. When an artery has been cut, pressure should be applied at the nearest available pressure point to control the bleeding. A pressure point is located where the artery is near the skin and across the bone. There are 24 pressure points—12 on each side of the body. Four of these are major pressure points, two on each side; they are shown in figure 1-10 as the pressure points nearest the tourniquet locations.

Arteries are tubes comparable to rubber tubing. If pressure is applied to them, their walls may be compressed so that the flow of blood can be retarded or cut off. Digital pressure can be applied by the fingers or by the heel of the hand. (See fig. 1-10.)

The scalp is supplied with blood by the temporal artery which passes about one-half inch in front of the ear, and the pressure point is on the temple. Pressure should be applied on the artery against the skull at that point. Usually a dressing for a wound of the head will permit an object to be placed beneath the cover dressing bandage and thus provide pressure on the artery.

A facial wound may be controlled by applying pressure to the facial artery which runs to the face from just below the angle of the lower jaw toward the nose. The point at which pressure should be applied is on the angle of the lower jaw where the artery crosses it. (See fig. 1-10, upper left drawing.)

The entire head is supplied with blood by the carotid artery that passes up from the outer edge of the breastbone to the angle of the jaw. Bleeding of the head may be controlled by applying digital pressure deep down and back, about an inch to the outer side of the larnyx.

The shoulder and arm are supplied with blood by the subclavian artery, which runs from the chest cavity just behind and along the upper edge of the collarbone into the armpit. Blood flow may be stopped by pressing down behind the collarbone against the neck. The same artery may be found in the armpit, and pressure may be applied to that point. Bleeding of the arm may be controlled by applying pressure to the same artery, now called the brachial artery, where it descends along the inner side of the large muscle. The artery should be pressed against the arm bone about 2 or 3 inches below the armpit. (See fig. 1-10, upper right drawing.)

Bleeding of the forearm may be controlled by closing the same artery in the bend of the elbow. The blood to the hand is supplied by two arteries, called the radial arteries, branching from the upper arm to the elbow. The first may be closed by pressure at the wrist, thumb side, just back of the joint, and the second at the wrist on the little finger side. Since these two arteries unite in the palm of the hand, both must be closed to stop bleeding in the hand.

The leg is supplied with blood by the femoral artery, which emerges from the interior of the body at the groin. At a point midway between the crotch and crest of the hip, the artery runs near enough to the surface

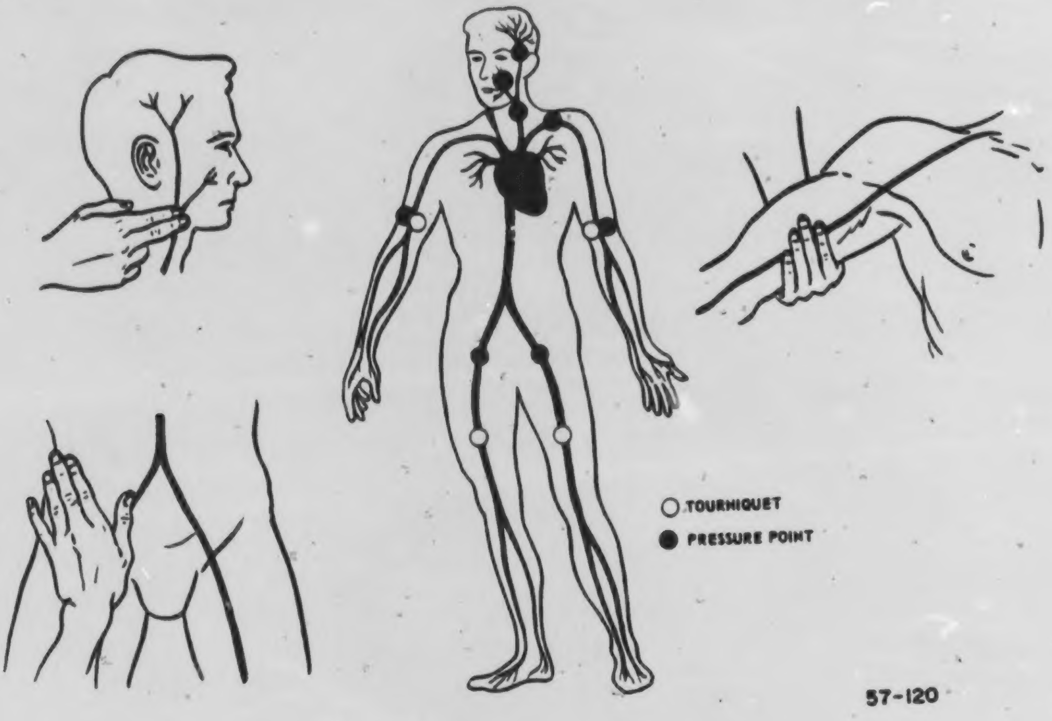


Figure 1-10. Pressure points.

to be compressed. To stop the blood flow, an object should be pressed deep into the groin at this point to press the artery against the leg bone (See fig. 1-10, lower left drawing.) The same artery may be found about 3 inches below the crotch, where it turns inward to pass on the underside of the bone. There it may be compressed by pressure against the thigh bone between the muscles. The artery then passes on the underside of the knee and divides to supply the lower leg. The flow of blood below the knee may be controlled by pressure in the center of the knee cavity.

Exercises (605):

1. What are the two basic methods used for the control of bleeding?
2. How is the pressure method of control applied?
3. What is the most effective method of controlling bleeding?
4. How is direct pressure applied?
5. If a wound is bleeding profusely and direct pressure on top of the wound is not effective, how should you control the bleeding?
6. If direct pressure fails to control bleeding, what should you do?
7. Where should digital pressure be applied?
8. How many major pressure points are there?
9. Where should pressure be applied to control bleeding from a facial wound?

10. Which artery supplies the leg with blood?

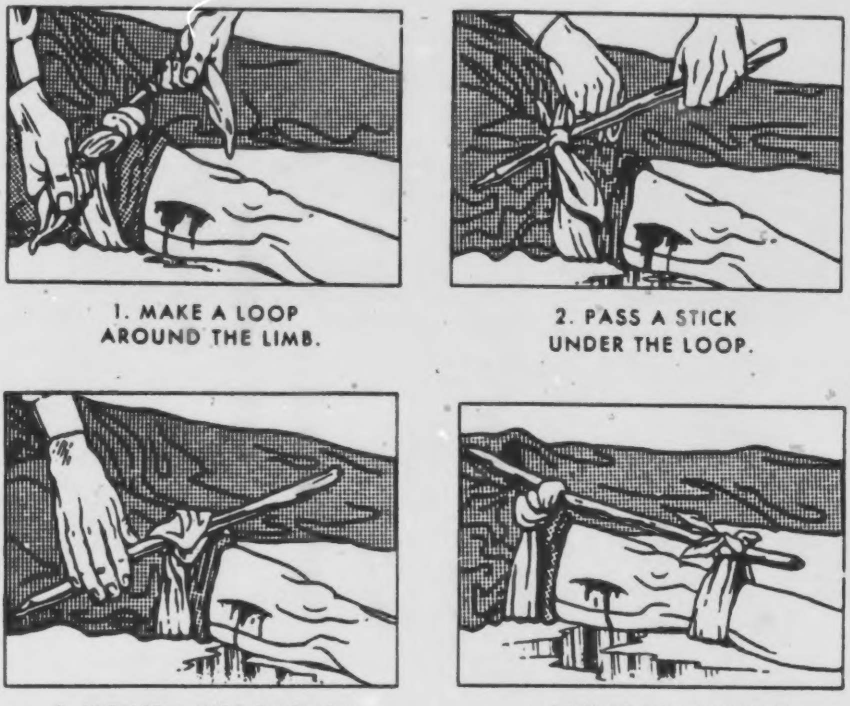
11. Where should pressure be applied to control bleeding from a wound below the knee?

606. Differentiate between proper and improper uses of a tourniquet and identify symptoms of internal bleeding.

Use of the Tourniquet and Constriction Band. The tourniquet should be used only for severe, life-threatening hemorrhage that cannot be controlled by other means. The use of the tourniquet as a method of controlling bleeding is mentioned principally to *discourage its indiscriminate use*. The application of a tourniquet may cause tissue injury, because it usually completely shuts off the entire blood supply to that part of the body to which it is applied. The pressure device itself often cuts into or injures the skin. Cases of partial or complete severance of a body part are the ONLY instances where application of a tourniquet can be justified. The victim should be taken to a physician as soon as possible after a tourniquet has been applied. Physicians or medical personnel who are prepared to control hemorrhage and replace blood volume should be the only ones permitted to release a tourniquet.

When the tourniquet is applied (see fig. 1-11), the time of application should be noted. Experience has shown that a properly applied constriction band will, in most cases, control bleeding to the degree where coagulation will stop the bleeding. This is particularly true if direct pressure is applied to the wound by a sterile compress. Improvised constriction bands should be made from some flat material about two inches wide, such as a stocking, a cravat bandage, or belt. Avoid the use of rope or cord, and do not use wire, string, or other materials of small circumference. Narrow, hard objects tend to cause injury to the underlying tissues and blood vessels. When making and using a constriction band, you should do the following: (1) select a soft, sturdy, and wide material for the band, (2) pass the band material around the limb or body member between the wound and the heart, (3) wrap the band tightly around the limb to stop or slow down the bleeding, and (4) cover the wound with a sterile compress.

Internal Bleeding. Some of the signs and symptoms of internal bleeding are a rapid and weak pulse; pale,



1. MAKE A LOOP AROUND THE LIMB.

2. PASS A STICK UNDER THE LOOP.

3. TIGHTEN JUST ENOUGH TO STOP BLEEDING.

4. SECURE TOURNIQUET IN PLACE.

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Figure 1-11. Applying a tourniquet.

moist skin; shallow and rapid respiration; thirst; a weak and helpless feeling; shaking and trembling; dilated pupils; coughing up bright red, frothy blood; or vomiting blood that has the appearance of coffee grounds.

Remember, a person may bleed to death and never lose a drop of blood on the outside. A good rule of thumb in estimating blood loss from badly contused tissues (closed wounds) is to figure an approximately 10 percent blood loss for each area of badly contused tissue the size of a man's fist.

There is little you can do to treat the internally bleeding patient. You should transport the patient immediately to a medical facility, treat for shock, and give nothing by mouth.

Exercises (606):

1. When should a tourniquet be used?

2. How may a tourniquet cause tissue injury?

3. Who should remove a tourniquet?

4. Why should you use wide constriction bands when controlling bleeding?

5. Describe the blood coughed up or vomited by a patient with internal injuries?

6. What is the rule of thumb used to estimate the blood loss from badly contused tissues?

607. Define shock, and state its causes and results.

The term "shock" carries many different meanings. To the average person, shock implies the passage of a powerful electrical current through the body, or a strong emotional response to a horrifying or disgusting sight. To medical and emergency care personnel, however, shock is the failure of a cardiovascular system to provide sufficient blood circulation to every part of the body.

The cardiovascular system is made up of the heart and the blood vessels that lead to and from the heart. Blood vessels change in size when signals, transmitted over the nerve pathways from the automatic nervous system, reach the muscles which contract or relax to control the diameter of the blood vessels. When the body is in a normal state, there is the exact amount of blood required to fill the cardiovascular system. As long as it remains full, every part of the body receives a regular supply of blood; the system is automatically filled by the pumping action of the heart, which develops sufficient pressure to move blood to the farthest point of the vascular system.

When something causes the cardiovascular system to lose its pressure or lose its fluid (both have the same effect), the body will be seriously affected and death can occur. Shock occurs when the system loses its volume (as in severe bleeding) or when the blood vessels dilate so widely that there is not sufficient blood to fill the system. Usually shock is associated with a traumatic situation or with a sudden illness.

The vessels of the cardiovascular system can open and close or, more precisely, dilate and constrict. The size of the blood vessels is changed by signals transmitted over nerve pathways from the automatic nervous system to the muscles in the blood vessels' walls. Stimuli such as heat, cold, and fear can cause blood vessels to dilate or constrict. However, it is important to note that changes in the blood vessels occur automatically; their size cannot be altered by mere exertion of human will.

When the body is in a normal state, there is just enough blood in the vessels to fill the system completely; that is, there are 12 pints in a space designed for 12 pints. Adequate and uninterrupted circulation of the system can be maintained only if the following conditions are met:

(1) The blood vessels must constantly change in size so that balance is maintained in the system.
(2) The system must be completely full of blood; and the heart must continue to operate at maximum efficiency.

Collapse of the cardiovascular system, or failure of the system to provide an adequate blood supply to all body tissues, may be attributed to one or more of the following situations:

(1) The blood vessels are dilated so widely that the blood supply fails to fill the system completely.
(2) There is a loss of blood.
(3) The heart fails to circulate the blood properly.

Whatever the reason for the collapse of the system, the result is the same: there is insufficient blood flow to provide all body tissues with oxygen and nourishment. Body processes slow down, and if circulation is reduced for a certain period of time, the vital organs begin to die. The old adage that "shock is one of the processes of dying" proves true.

Exercises (607):

1. What is shock in first aid work?

2. When does shock occur?

3. What causes the blood vessels to dilate or constrict?

4. What may cause collapse of the cardiovascular system, or failure of the system to provide an adequate blood supply to all body tissues?

5. When the body processes slow down and circulation is reduced for an extended period of time, what will happen to the vital organs?

608. Name types of shock and state their causes.

It is important to understand that shock may accompany many emergency situations. Thus, treatment for shock is included in emergency care procedures for almost every injury or medical emergency. Types of shock are described in the following paragraphs.

Hemorrhagic Shock. Hemorrhagic shock results from blood loss. A reduction in the body's blood volume means that there is not sufficient blood to fill the system; thus, circulation is impaired and shock results. Blood volume can be reduced by: (1) external bleeding, as from open wounds; (2) internal bleeding, as associated with injuries to the chest or abdomen, fractures, massive contusions, and crushing injuries; and (3) loss of plasma (the liquid part of the blood), as in the case of burned or crushed tissues.

Respiratory Shock. Respiratory shock is caused by insufficient oxygen in the blood. This results from inability to fill the lungs completely. There are several reasons that breathing may be impaired. An airway obstruction can prevent a sufficient amount of air from reaching the lungs. Spinal cord damage can paralyze the muscles of the chest wall, causing the patient to breathe with his diaphragm alone. Injuries to the chest cavity which interfere with normal lung operation.

The first-aider should be aware that respiratory shock, unlike the other types of shock, is not caused by impairment of circulation. At the outset, the heart is operating normally with a proper amount of blood and the blood vessels are constantly adjusting to keep the system full. However, the oxygen supply available for exchange in the lungs is not normal; consequently, the blood is not properly oxygenated. An inadequate air exchange in the lungs can produce shock as quickly as blood loss.

Neurogenic Shock. Neurogenic shock is caused by loss of control of the nervous system. If the spinal cord is damaged in an accident, nerve pathways between the brain and the muscles are interrupted at the point of injury. As a result, the muscles controlled by the damaged nerves are temporarily or permanently paralyzed, including the muscles of the walls of the blood vessels. The blood vessels can no longer change size in response to stimuli from the nervous system, and they remain widely dilated. A greater amount of blood is required to fill the vessels; and, since the cardiovascular system has only enough blood to fill the vessels in a normal state, circulation is impaired and shock develops quickly.

Psychogenic Shock. Psychogenic shock is commonly known as fainting. Simple fainting is a reaction of the nervous system to certain stimuli such as fear, bad news, the sight of blood, or a minor injury. Suddenly, dilation of the blood vessels occurs, and the blood flow to the brain is momentarily interrupted. The person falls unconscious, or faints. Unless other problems are present, fainting is usually self-correcting. As soon as the head is lowered, blood circulates to the brain and normal functions are restored. Fainting can often be prevented if the head is lowered before loss of consciousness (i.e., by sitting down and placing the head between the knees).

Cardiogenic Shock. Cardiogenic shock is due to inadequate functioning of the heart. Proper blood circulation depends on an efficient and continuous heart operation, but certain diseases and disorders weaken the heart muscle and cause it to operate at a reduced output. When the heart can no longer develop the pressure required to move blood to all parts of the body, circulation is impaired and shock results.

Septic Shock. Septic shock is caused by severe infection. In cases of severe infection, toxins released into the bloodstream have a harmful effect on the blood vessels. The poisonous substances cause the vessels to dilate and further complications by causing the loss of plasma through the vessel walls. Circulation is impaired in two ways: (1) incomplete filling of the system due to the wide-spread dilation of the vessels, and (2) a reduction in blood volume.

The first-aider rarely encounters septic shock since it is associated with prolonged periods of hospitalization due to serious illness or surgery.

Metabolic Shock. Metabolic shock is caused by loss of body fluids and changes in body chemistry. This type of shock results from an excessive loss of body fluids through diarrhea, vomiting, or urination. Metabolic shock may also be caused by severe disturbance of body salts or of the acid-base balance in diseases, such as diabetes. Like septic shock, this disorder is rarely encountered by the first-aider.

Exercises (608):

1. What type of shock results from blood loss?

2. What causes shock due to the loss of blood?

3. What causes respiratory shock?

4. Damage to the spinal cord would be what type of shock?

5. How could damage to the spinal cord cause shock?

6. Psychogenic shock is commonly known as what?

7. What causes psychogenic shock?

8. What type of shock is caused by severe infection?

9. Metabolic shock is caused by what?

10. Of the types of shock discussed, which two are rarely encountered by the first-aider?

609. Identify the signs and symptoms of shock and state how shock should be treated.

Signs and Symptoms. Although shock is a very serious condition, it is by no means hopeless or irreversible; much can be done for the patient if the problem is quickly recognized and efficiently treated. See figure 1-12. The symptoms of shock are as follows:

- Eyes are dull and lack luster, a sign of poor circulation.
- The pupils are dilated, another sign of poor circulation.
- The face is pale and may be cyanotic. Cyanosis is an important sign of oxygen deficiency, in this case caused by reduced circulation.
- Respiration is shallow, possibly irregular, or labored. The vital centers that regulate respiration are slowing down, as are all life processes.
- The pulse is weak and rapid, because the heart is working faster to compensate for reduced blood pressure and volume.
- The skin is cold and clammy, since the blood has left active circulation in the extremities and is pooling in the vital organs.
- There may be nausea, collapse, vomiting, anxiety, and thirst.

Treatment. Treatment of shock takes priority over all other emergency care measures except for the correction of breathing problems, the reestablishment of circulation, and the control of profuse bleeding. Proper treatment involves caring for the whole victim, not just one or two of the disorders. The following steps should be taken in caring for a patient in shock.

Assure adequate breathing. If the victim is breathing, maintain an open airway by properly positioning his head. If the patient is not breathing, establish an airway and restore breathing through some means of pulmonary resuscitation. If both respiration and circulation have stopped, institute cardiopulmonary resuscitation immediately.

Control bleeding. If the patient has bleeding injuries, take corrective action.

Elevate the lower extremities. Since blood flow to the heart and brain may have been diminished, circulation can be improved by raising the legs slightly. It is not recommended that the entire body be tilted down at the head, since the abdominal organs pressing against the diaphragm may interfere with respiration. Exceptions to the rule of elevating the legs are cases of head and chest injuries, where it is desirable to lower the pressure in the injured parts; in these cases, the upper torso should be elevated slightly. Whenever there is any doubt as to the best position, the victim may be laid perfectly flat without adverse effects.

Avoid rough handling. Handle the victim as little and as gently as possible. Body movement usually aggravates shock conditions.

Prevent loss of body heat. Keep the victim warm but guard against overheating. Place blankets under and over him to prevent loss of heat.

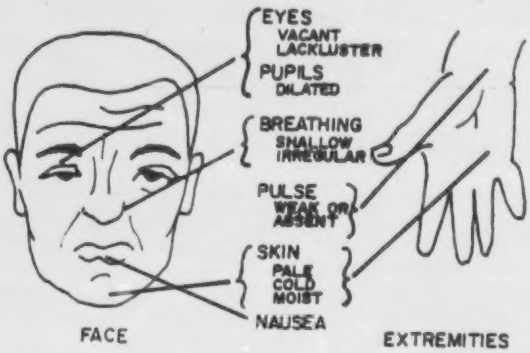

Figure 1-12. Signs of shock.

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Keep the victim lying down. This avoids exertion on the circulatory system when it should be at rest. NOTE: Some victims, such as those with heart disorders, will have to be kept in the sitting position throughout emergency care.

Give nothing by mouth.

REMEMBER: Your objective as a first-aider for a victim in shock is to prevent or reduce shock. The above methods have been proven most effective for that purpose.

Exercises (609):

1. What are the signs of shock?

2. What steps should be taken to treat for shock?

3. Why should a victim in shock be kept lying down?

4. What should a victim in shock be given to drink?

1-2. Cardiopulmonary Resuscitation (CPR)

Even in this age of highly sophisticated and automated machines, a factory worker must know a great deal more about the machine than the mere fact that it performs a certain function and that a single switch or lever causes it to do its work. He must know how the machine works and—what is more important—what to do if it malfunctions or fails. The same is true of the first-aider. It is not enough for you to know that the human body is a wonderful and complex machine that may operate for years with only minimal care and with a remarkably low breakdown rate. You must know how the machine works and what to do in case any of its major parts malfunction or fail.

610. State how the heart, lungs, and brain are interdependent.

The human machine continues to function efficiently because of a close relationship among the heart, the lungs, the brain, and their interconnecting blood vessels. Each of the organs is dependent on the others, and each will continue to function only as long as the others operate properly.

The heart pumps blood to the lungs, where it is combined with oxygen that is drawn into the lungs with each breath. The oxygen-enriched blood returns to the heart and is immediately pumped to all parts of the body, where the oxygen is exchanged for waste products. (See fig. 1-7.)

While all of the cells of the body need a constant and uninterrupted supply of oxygen for nourishment and revitalization, nowhere is this supply more essential than in the brain. In addition to regulating all of the other functions, the brain controls the activity of the heart. As long as the cardiac control center in the brain is properly fueled by a fresh supply of oxygen, it continues to send the signal that causes the heart to pump efficiently and without interruption. Thus, it is quite easy to see that life continues as long as the operation of the heart, lungs, and brain are properly balanced.

On the other hand, if something happens to upset this balance, the body is placed in immediate danger. Unless the condition causing the disturbance is corrected promptly and efficiently, death may result. In many cases, death is expected and is inevitable. For example, advanced age coupled with terminal illnesses may cause the cells of vital organs to deteriorate to the point where they simply can no longer function, and the body dies. On the other hand, the sudden and unexpected death of an otherwise healthy person can be preventable if the proper resuscitative steps are taken immediately. Victims of drowning, electric shock, heart attack and asphyxia, for instance, do not have to die.

In many accident situations, the chain of events that leads to death is initiated by the inability of the patient to breathe. Since no fresh air is provided to the lungs, no oxygen supply is available to the blood stream. Even though the heart continues to pump, no oxygen is carried to the cells of the brain. The brain cells are weakened by the lack of fuel, and the cells that make up the cardiac control center quickly lose their ability to send signals to the heart. Because it is not receiving stimuli from the brain, the heart falters and stops, and the patient is in a state of cardiac arrest.

At the moment when heart action stops, and when respiration and the other usual signs of life are absent, a patient is said to be clinically dead. However, even though respiration and heart action have stopped, the cells of the body will live for a short time until their supply of residual oxygen is used up. The length of time that the cells will live depends a great deal on their need for oxygen. Some cells, such as those found in cartilages of the joints, may live for hours while other cells die very quickly. For example, the cells of the brain die from 4 to 6 minutes after being deprived of oxygen and blood. At the end of this period, irreversible brain damage has occurred and the patient has passed into the state of biological death, from which there is no return.

Even though the period between clinical death and biological death is extremely short, a patient may be successfully resuscitated if oxygenated blood can be circulated throughout the body by some artificial means until the heart can operate on its own once again, though some brain damage may occur in the interim.

Remember, absence of oxygen in the brain for any amount of time may result in a certain amount of brain damage, but after 4 to 6 minutes, irreversible cell damage and death are almost inevitable. As the time without oxygen increases, the patient's chances of recovery decrease rapidly. Thus, successful treatment of cardiac arrest is directly related to the speed and efficiency with which such treatment is applied.

Exercises (610):

1. The heart, lungs, and brain are dependent upon what to continue their function?

2. Explain how the heart, lungs, and brain maintain their proper balance.

3. How does the lack of fresh air disturb the balance between the heart, lungs, and brain?

4. What is the difference between clinical death and biological death?

5. Brain cells die if they do not receive oxygen for what period of time?

611. Define cardiopulmonary resuscitation and state the physiological facts which make it possible.

Cardiopulmonary resuscitation is another name for heart-lung resuscitation, or the combination of efforts to restore breathing and circulation artificially. Though there are many mechanical devices that can be used to perform both phases of cardiopulmonary resuscitation, and equally as many devices that can be used for the ventilation phase, we suggest use of the manual method. The manual method is very effective; it requires no sophisticated equipment that is subject to failure and no preparation time.

Physical Structures. In order to perform the techniques of cardiopulmonary resuscitation properly, you must be familiar with the relationship of the heart to the other structures of the chest, and to the chest itself. This awareness not only makes it easier to learn the procedure but also serves to stress the dangers of performing cardiopulmonary resuscitation incorrectly.

The heart is located between the lungs, with about two thirds of its bulk situated to the left of the midline of the body. Located in the middle of the chest is the sternum (breastbone), which is a flat, bony structure that joins the ribs in front of the chest. At the lower end of the sternum is a bony prominence, called the xiphoid process, that curves inward. The xiphoid process plays an important part in the positioning of the operator's hands when performing cardiopulmonary resuscitation. The upper end of the sternum is joined to the clavicle (collarbone). The ribs provide a protective cage for the lungs, which lie directly below them, and to some extent for the liver, which lies below part of the sternum. Figure 1-13 shows the major bones of the body.

Mechanics of Artificial Circulation. Artificial circulation is produced when the chest is compressed from 1½ to 2 inches, which, in turn, squeezes the heart between the sternum and the spine. (See fig. 1-14.) When the heart is squeezed in this fashion, blood is forced into the pulmonary circuit to the lungs, where it is oxygenated, and into the systemic circuit, through which it travels to all parts of the body. When pressure on the sternum is relaxed, the elastic chest wall causes the sternum to spring outward to its original position. The release of pressure on the heart results in a sucking action that draws blood into the heart from the veins and the lungs. The blood is kept in constant motion as long as the heart is squeezed and released by external chest compressions. The efficiency of properly performed cardiopulmonary resuscitation is approximately 35 percent of that of a normally operating heart.

Exercises (611):

1. What is cardiopulmonary resuscitation?

2. What method of cardiopulmonary resuscitation is suggested for use by most firefighters?

3. Why should you be familiar with the relationship between the heart and chest and other structures of the chest?

4. How is artificial circulation produced?

5. What causes the sternum to return to its original position when pressure on the sternum is relaxed?

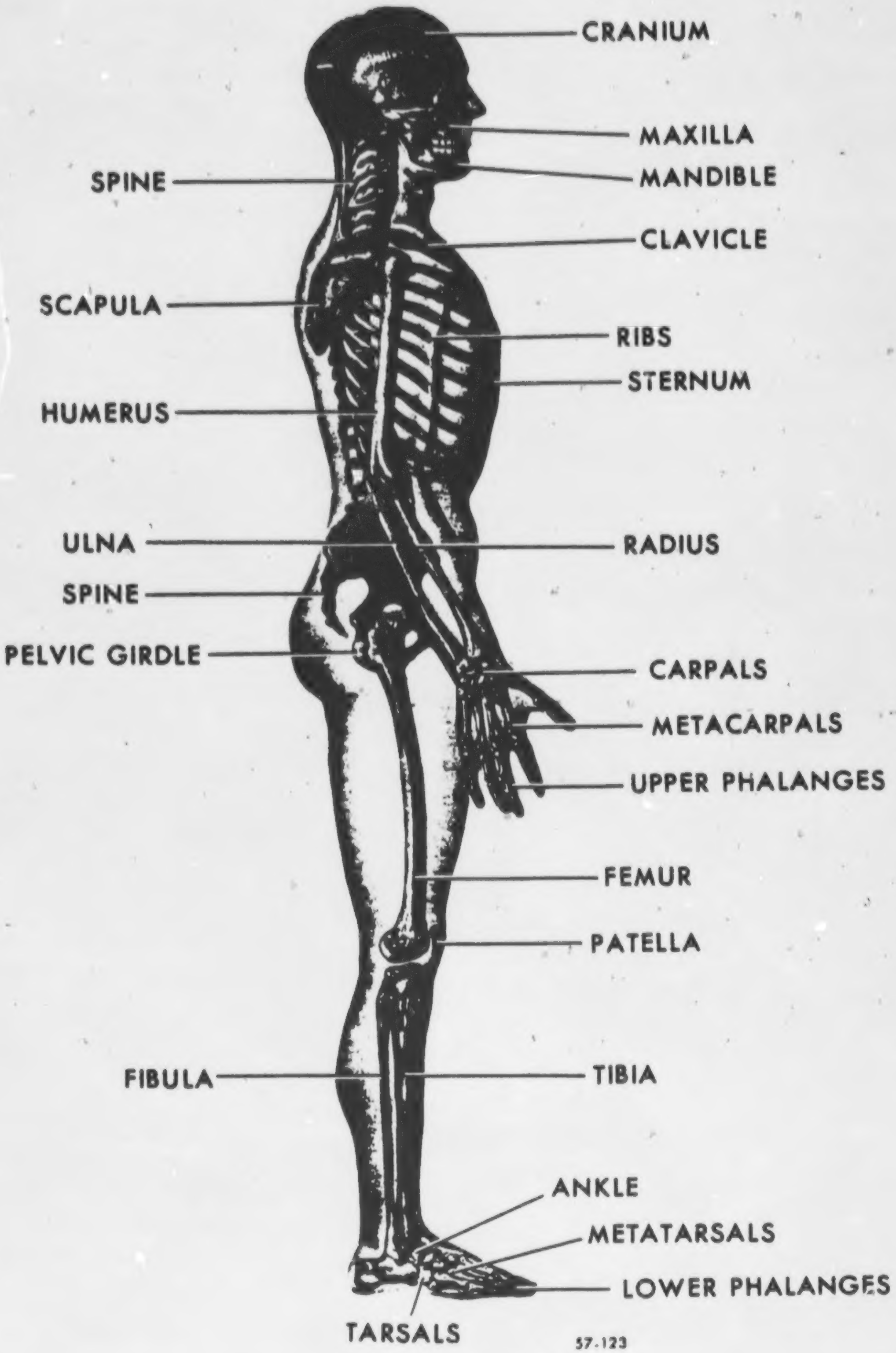
CRANIUM
MAXILLA
SPINE
MANDIBLE
CLAVICLE
SCAPULA
RIBS
STERNUM
HUMERUS
ULNA
RADIUS
SPINE
PELVIC GIRDLE
CARPALS
METACARPALS
UPPER PHALANGES
FEMUR
PATELLA
FIBULA
TIBIA
ANKLE
METATARSALS
LOWER PHALANGES
TARSALS
57-123

Figure 1-13. Major bones of the body.

5. When cardiopulmonary resuscitation is properly performed, it is approximately how effective in comparison with a normally operating heart?

612. Specify the procedures for cardiopulmonary resuscitation.

Techniques of Cardiopulmonary Resuscitation. Remember, cardiopulmonary resuscitation is a combination of efforts to maintain breathing and circulation artificially until the normal heart-lung relationship is restored.

Also remember that, when a patient is in cardiac arrest, artificial circulation is ineffective without artificial ventilation since otherwise there is no means of oxygenating the blood that is being circulated. By the same token, when a victim is in cardiac arrest, artificial ventilation is ineffective without artificial circulation since ventilation provides no means of circulating the blood. The sequence of operations required in cardiopulmonary resuscitation is best remembered by the ABC technique.

"A" stands for airway. Assure that the patient has a clear airway, that the head is in the proper position, and that the throat is free from foreign objects.

"B" stands for breathe. Inflate the patient's lungs immediately with three quick, double-sized breaths, using mouth-to-mouth technique, or mouth-to-nose if necessary. This will provide a high concentration of oxygen in the lungs that is immediately available for circulation to the brain.

"C" stands for circulate. Properly situate the patient, locate the pressure point, place your hands properly, apply pressure, and interpose ventilations.

The patient in a cardiac arrest must be placed on a hard and unyielding surface, such as a floor or the ground. If he is on a bed or an ambulance cot, a spine board backboard, serving tray, or similar object should be slipped underneath his back. Attempting to compress a patient's chest while he is on a mattress or other soft surface results only in pushing the entire body downward. It is important to determine the exact point on the sternum where pressure must be applied when compressing the chest. The sternum is hard and the abdomen is soft, so the point where they come together can be found easily. It is equally as easy to find the upper end of the sternum by locating the notch where the sternum attaches to the collarbone. The pressure point is in the center of the lower half of the sternum. Pressure must be applied to this point and nowhere else if the technique is to be effective and damage to other structures avoided. This is extremely important.

The heel of one hand is placed over the pressure point, and the heel of the other hand is placed over the back of the first. The fingers of each hand should be held outward and as high as possible so that contact with the ribs is avoided. You should position yourself over the patient, close enough so that you can apply pressure downward vertically, thus utilizing the entire weight of your upper body. Remember, any deviation from this procedure for placing the hand may result in damage to the ribs and underlying organs.

In order for adequate blood circulation to take place, the heart must be compressed with firm, heavy pressure. While the amount of pressure depends on the age and size of the patient, the sternum is generally compressed about 1½ to 2 inches. The sternum is held down

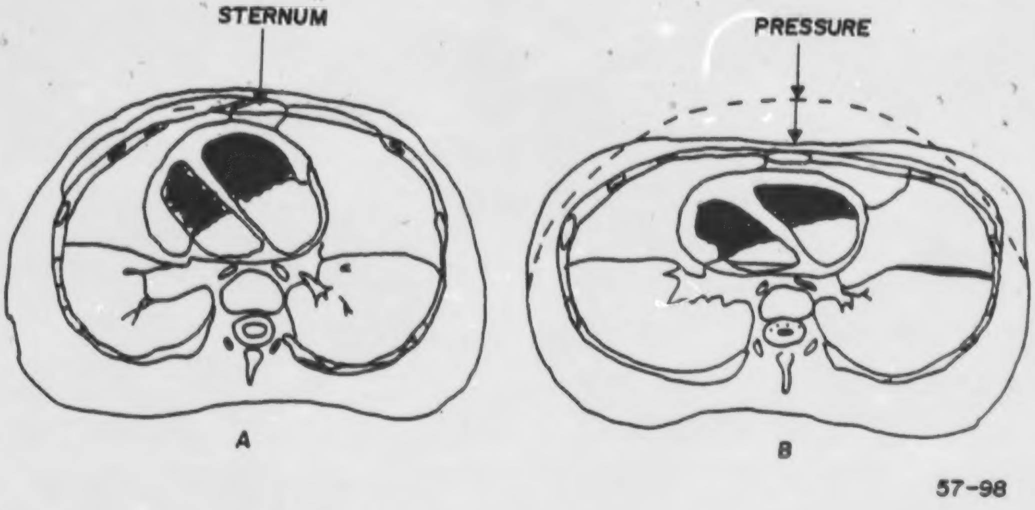

Figure 1-14. Mechanics of cardiac compression (artificial circulation).

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for about a half second, and then is quickly released. Compressions are made at the rate of about 60 to 80 per minute. The compressions must be continued until the patient shows signs of recovery, or until qualified personnel take over. Cardiopulmonary resuscitation efforts SHOULD NOT BE INTERRUPTED FOR ANY REASON and should be continued even while the patient is being loaded onto the ambulance or unloaded at the hospital.

You *must* maintain the proper rate at any cost. Any rate lower than the 60/80 described above will result in disaster. Once the rate has been started, it must not be interrupted for any reason for more than 5 seconds.

Remember, chest compressions without ventilation are of little value to the patient since the only air exchange is that which might result from the chest movements caused by their compression efforts. This limited exchange is not sufficient to oxygenate the blood.

To provide the pulmonary phase of cardiopulmonary resuscitation, some means of artificial ventilation must be supplied by the mouth-to-mouth or mouth-to-nose techniques, by a bag mask resuscitator, or by mouth-to-airway method. Pressure-cycled resuscitators should not be used since the cycling of the machine can be interrupted by the chest compressions, resulting in insufficient supply of air to the patient's lungs. On the other hand, ventilation with a volume-cycled resuscitator is highly desirable if such equipment is available. This technique provides the patient with a much greater concentration of oxygen in a short time, which greatly speeds his recovery.

When it is necessary to perform cardiopulmonary resuscitation (CPR) alone, you should proceed as follows:

(1) Place the patient on his back on a hard surface, preferably the floor or ground.

(2) Upon determining that the patient is in cardiac arrest (by checking the three signs), immediately establish the airway and ventilate the patient with three double breaths.

(3) Shift to the patient's side and compress the chest 15 times at a rate of 60 to 80 times per minute, making sure that your hands are always in the proper position.

(4) After the 15th compression, quickly pivot back to the patient's head and inflate the lungs two times without a pause between ventilations.

(5) Return to the chest and compress the chest 15 times.

(6) Repeat the cycle of 15 chest compressions to two ventilations without interruption until the patient shows signs of recovery or until you are relieved by competent personnel.

Exercises (612):

1. How is the sequence of operations required in CPR best remembered?

2. In the ABC technique, what do the letters ABC stand for?

3. Why must a patient in cardiac arrest be placed on a hard, unyielding surface?

4. Where is the pressure point for giving CPR located?

5. What will happen if pressure is applied at the wrong point during CPR?

6. Describe how the hands are placed on the pressure point.

7. In CPR, the sternum is generally compressed about how much?

8. Compressions should be made at the rate of _____ to _____ per minute.

9. For how long must the compressions be continued once CPR has been started?

10. How is the pulmonary phase of CPR provided?

11. Why should pressure-cycled resuscitators not be used?

12. When performing CPR, what is done after the patient is placed on his back and the determination has been made that he is in cardiac arrest?

13. During CPR, how often should the patient be ventilated?

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14. Each ventilation cycle of CPR should consist of inflation of the patient's lungs _____ times with how much of a pause between them?

613. Specify how two first-aiders perform CPR and how CPR is administered to children.

CPR With Two First-Aiders. The most effective cardiopulmonary resuscitation can be accomplished by two first-aiders working together. The two-man method is not only more effective but also far less tiring than working alone. When two persons are working together, they should proceed as follows:

- Place the patient on a hard surface.
- Determine the patient's condition through the three signs.
- One person should be positioned at the patient's head. He should establish an open airway and quickly ventilate the patient with three double-sized breaths.
- The other person should be positioned at the patient's side opposite the first and start manual compression at the rate of one every second as soon as the patient is ventilated. Whoever is at the head then interposes a quick double-size breath after every five (5) chest compressions. Repeat this one-to-five cycle without interruption until relieved. It is best that the two first-aiders be on opposite sides while performing two-man cardiopulmonary resuscitation to ensure a smoother change of positions if fatigue causes a need for a change.

Technique for Children. The procedures for performing chest compression on children are different from those used for adults in that much less pressure is required. However, a faster compression rate should be used to compensate for the child's faster heartbeat. For children weighing less than 80 pounds, use the heel of one hand only. For infants, use only the tips of the fingers. Do not press too hard, for the heart muscle of an infant is easily bruised.

An easy way to perform cardiopulmonary resuscitation on an infant is to cradle him on your arm, with his head supported in your hand. In this position, it is easy to compress the chest and to interpose the breaths.

REMEMBER: Much less effort should be used when ventilating a child. When ventilating an infant, only PUFFS from the cheeks should be used.

Exercises (613):

1. How is the most effective CPR accomplished?

2. Where do the two persons giving CPR position themselves in relation to the patient?

3. When two persons are performing CPR, how often is the patient ventilated?

4. When performing CPR on an infant, how should you use your hands?

5. Describe the ventilation cycle of CPR for infants.

614. State how to judge the effectiveness of cardiopulmonary resuscitation and the results of poor CPR techniques.

Effectiveness of CPR Efforts. If the patient can be successfully resuscitated—that is, if biological death has not occurred, the effectiveness of cardiopulmonary resuscitation efforts can be measured by certain changes in the patient's condition. If the efforts are successful, the following changes will occur: the pupils of the eyes MUST constrict; the patient's color MUST improve; a pulse MUST be felt at the carotid artery with each cardiac compression.

A change in pupil size and a freshening in the patient's skin color are both good indications that the oxygenated blood is being circulated. A carotid pulse felt at the time of each chest compression is an indication that the heart is being squeezed sufficiently to circulate the blood.

In addition to changes that MUST occur if cardiopulmonary resuscitation efforts are effective, the following changes MAY occur: spontaneous respiration MAY begin, and the arms and legs of the patient MAY move.

The return of spontaneous respiration is an indication that the heart-lung-brain relationship has been restored and is returning to a normal state and that normal heart action will result. At this point, the patient may need only to be watched carefully, or at the most to have his breathing supported.

You should not be discouraged if the patient does not start spontaneous circulation and breathing even after proper CPR methods have been used. In most cases, the patient will not fully recover until definitive (in the hospital with drugs and complicated treatments by physicians) care has been given. You are the patient's vital link with life between the time his circulation stops and he reaches the hospital.

Complications of Cardiopulmonary Resuscitation. Damage to the thoracic cage or chest cavity and the underlying organs can be caused by improper placement of the hands during chest compression. When the hands are placed too far to the right, the ribs may be fractured, causing lacerations to the lungs and possibly to the heart muscle itself. When the hands are placed too far to the left, ribs may be fractured and the underlying lung tissue lacerated. When the hands are placed too low, there is the possibility that the bony prominence called the xiphoid process may be depressed too far, thus lacerating the liver. When the hands are placed too high, the collarbone may be broken where it joins the sternum.

Even with the hands placed in the proper position on the sternum, there is a possibility that the force required to compress the chest adequately will be sufficient to break ribs. However, it would obviously be far better for the patient to suffer the temporary discomfort of a few broken ribs than die.

Exercises (614):

1. What are the three MUSTS in a patient's condition when CPR is effective?

2. How can you tell if oxygenated blood is being circulated in a patient?

3. What is the return of spontaneous respiration an indication of?

4. What may happen if the hands are placed too far to the right during chest compression?

5. What organ may be lacerated if the hands are placed too low during compression?

1-3. Pulmonary Resuscitation.

If an airway has been established and spontaneous breathing is still not evident, you must take immediate steps to ventilate the lungs of the patient artificially. There are several methods of artificial ventilation, or pulmonary resuscitation, such as mouth-to-mouth resuscitation, a mouth-to-airway device, a mechanical resuscitator, or a bag mask resuscitator. However, mechanical devices are not always readily available, and trying to locate one may take valuable time. The patient at times cannot afford to wait for mechanical resuscitation, so other means must be used. Irreversible brain damage occurs within 4 to 6 minutes after the cells of the brain are deprived of their oxygen supply.

615. List the advantages of mouth-to-mouth resuscitation.

The one method of providing pulmonary resuscitation that is far superior to all other techniques is mouth-to-mouth resuscitation.

Advantages of Mouth-to-Mouth Resuscitation. The mouth-to-mouth technique of pulmonary resuscitation has several distinct advantages.

- It requires no special equipment—nothing to find, nothing to set up, and nothing to malfunction.
- It requires only one person to administer.
- It can be applied immediately in almost any situation.
- It provides the lungs with maximum ventilation.
- It frees your hands so that you may use them to maintain an airway, compress the stomach to expel the air, or feel for a pulse in the carotid artery.
- It is less fatiguing to the first-aider than the body-manipulation method.
- It is easier to gauge the effectiveness of the resuscitative effort, since you can feel the lungs expand, see the chest rise, and hear the air escape during exhalation.

Exercises (615):

1. Mouth-to-mouth resuscitation is far superior to all other techniques for providing ________ resuscitation.

2. What are the advantages of mouth-to-mouth resuscitation?

3. What is the advantage of not needing any special equipment?

4. How is having your hands free an advantage in giving mouth-to-mouth resuscitation?

5. Why is it easier to gage the effectiveness of resuscitative effort with mouth-to-mouth resuscitation?

616. Specify the techniques of mouth-to-mouth, mouth-to-nose, and mouth-to-stoma resuscitation.

Techniques of Mouth-to-Mouth Resuscitation. The method of mouth-to-mouth resuscitation has been proven clinically to be the most effective means of artificially ventilating a nonbreathing person. First clear the mouth, and then tilt the head back. With the air passage maintained by maximum extension of the head, pinch the victim's nose shut with your thumb and forefinger. This will prevent air from escaping when you blow into the victim's mouth. Take a deep breath, open your mouth wide, and place it over the mouth of the victim, making a tight seal. Quickly blow your breath into the patient's mouth until you can feel the resistance by the expanding lungs and see the chest rise. Then, remove your mouth and allow the victim to exhale. If you need the use of your hands, you may elect not to pinch the victim's nose. Instead, the side of your face can serve as a blockage to the victim's nose.

For adult victims, the breathing cycle is repeated every 5 seconds, or about 12 times each minute. Each breath should provide at least 1,000 cc, or about 2 pints of air. This is twice the amount of air normally inhaled. Since expired air contains about 16 percent oxygen and 4 or 5 percent carbon dioxide, the double-sized breaths assure adequate oxygenation of the blood and removal of carbon dioxide from the patient's lungs.

For infant victims, mouth-to-mouth breathing requires a slightly different technique than that just described. One good position for mouth-to-mouth breathing for children and infants is illustrated in figure 1-15. It is usually advantageous to place your mouth firmly over the infant's mouth and nose; the respirations must be applied gently. Use only puffs from your cheeks for infants. When the victim's chest rises, remove your mouth and let the victim exhale. Repeat the inflations about 20 times per minute.

Techniques of Mouth-to-Nose Resuscitation. For mouth-to-nose resuscitation, you elevate the lower jaw of the victim as described previously. Then place your mouth over the victim's nose and blow to inflate the lungs. your cheek may be used to seal the victim's lips, or one finger may be placed over them to prevent air leakage. This method may be tried should the attempt to penetrate air through the victim's mouth prove unsuccessful. This alternate method is often used when the victim has serious injuries to the lower jaw or a severely receding chin due to lack of natural teeth or absence of dentures.

Mouth-to-Stoma Resuscitation. A stoma is a breathing tube inserted in a neck-breathing person. There are two types of neck-breathing patients. The tracheostomy patient and the laryngectomy patient. It is important to remember the difference between the two. The tracheotomy victim has an opening both through the mouth nose and in the neck. The laryngectomy patient has an opening only in the neck.

When performing mouth-to-stoma resuscitation on the tracheotomy victim, you will be inflating the lungs through the stoma. You must close the upper airway by pinching the victim's nose and keeping his mouth shut. Clearing the mouth is not necessary, and extension of the victim's head may not be necessary. Otherwise, the same procedure is followed as in the mouth-to-mouth technique.

The technique for the laryngectomy victim is the same as the mouth-to-mouth technique, except that the lungs are inflated through the stoma and clearing the mouth and extension of the head is not necessary.

Exercises (616):

1. How is the air passage maintained?

2. How do you prevent air from escaping when you blow into a victim's mouth?

3. How do you determine when to stop blowing air into a victim's mouth?

4. The breathing cycle is repeated how often for adult victims?

5. Why should you use double-size breaths when giving mouth-to-mouth resuscitation?

6. Inflation should be repeated at a rate of about _____ times per minute for infants.

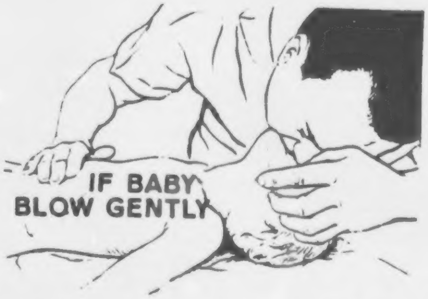

Figure 1-15. Mouth-to-mouth resuscitation for infants.

7. When using mouth-to-nose resuscitation, how are the victim's lips sealed?

8. When should you try to use the mouth-to-nose method?

9. Why is it important to know the types of neck-breathing patients?

10. What steps required in mouth-to-mouth resuscitation are not necessary for mouth-to-stoma resuscitation?

1-4. Mechanical Aids to Breathing and Pulmonary Resuscitation

Given the basic steps for artificial ventilation, you should be aware of the numerous devices that can make your efforts of resuscitation easier. To learn the operation of these devices requires very little time, but it will require constant practice for you to maintain your efficiency.

In a previous section, you learned the construction of the respirtory system and steps for ventilation. Now you will become acquainted with various devices that will make your job easier and improve your efforts, the oropharyngeal airway and its uses, and the bag mask resuscitator.

617. Define oropharyngeal airway and state how it is used.

Oropharyngeal Airways. Oropharyngeal airways are curved breathing tubes which, when inserted in the patient's mouth, hold the base of the tongue forward so that it does not block the air passage. You cannot depend completely upon this type of device, however, because the head must be tilted backwards to provide the maximum opening. Two basic guidelines should be followed to determine whether or not an airway is to be used.

- When the patient is found to be conscious and breathing normally, no attempt should be made to insert an airway, primarily because the patient will not accept it.
- When the patient is found to be unconscious with breathing obstructed, an airway should be inserted if breathing remains obstructed in spite of head tilt and attempts at artificial ventilation.

If the patient reacts by swallowing, retching, or coughing after an artificial airway is in place, the airway must be removed quickly because vomit increases the likelihood of airway obstruction. Artificial airways should be employed only when the user is trained in their use. To insert an oropharyngeal airway, the following steps should be used:

Step 1. Using one hand with the thumb and index finger crossed, pry the patient's teeth apart and hold the mouth open.

Step 2. With the other hand, insert the airway between the patient's teeth with the curve backward at first, then turn it to the proper position as you insert it deeper. This twisting maneuver prevents the tongue from being pushed further back into the throat.

Step 3. If you have any difficulty with the tongue, hold it forward with your index finger.

Step 4. If jaws are too firmly clenched for the mameuver described above, try to wedge them apart by inserting your index finger between the patient's cheek and teeth, forcing the tip of your finger behind the back teeth. If you have difficulty forcing the teeth apart or inserting the airway, do not persist, but hold the head backwards and use mouth-to-nose resuscitation.

Both methods for forcing the mouth open are useful not only for airway insertion but also for wiping or suctioning the air passage.

Exercises (617):

1. What is an oropharyngeal airway?

2. When should an oropharyngeal airway NOT be used?

3. How is the airway inserted?

4. What should you do if you have trouble with the victim's tongue while inserting an airway?

618. Specify the procedures for mouth-to-airway ventilation and bag mask resuscitation.

Mouth-to-Airway Ventilation. The mouth-to-airway unit (commonly called the S-tube) and various other mouth facepiece units are tools that have been introduced to overcome objection to direct mouth-to-mouth contact. (See fig. 1-16.) These devices should be used only if the operator is trained in their use and only if they are immediately available. To use a mouth-

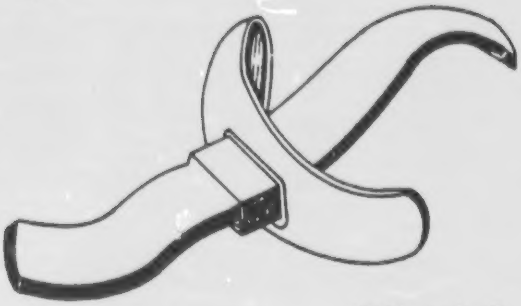

Figure 1-16. Artificial airway (S-tube).

o-airway device, the following steps should be taken:

- Tilt the patient's head backwards and insert the airway in the manner described for oropharyngeal airways. (See fig. 1-17.) When using the S-tube, make sure that the cupped flange is properly positioned. (See fig. 1-18.)
- Prevent leakage by pinching the patient's nose closed and pressing the flange firmly over the mouth. Hold the chin up so that the front of the neck is stretched. (See figs. 1-18 and 1-19.)
- Follow all of the other steps required for mouth-to-mouth technique, such as rate and size of breaths.

Bag-Mask Resuscitation. Another valuable device that may be used for artificial ventilation is the bag-mask resuscitator. (See fig. 1-20.) This device consists of a face mask fitted to a self-inflating bag with a special valve arrangement that allows the bag to refill and the patient to exhale without the removal of the unit from his face. A common problem experienced with this type of equipment is failure of the operator to hold the facepiece firmly enough against the patient's face, resulting in an inadequate seal. The bag-mask resuscitator should be used in the following manner:

- Hold the facepiece over the patient's face and clamp it securely in place with one hand. Press your thumb over the rim of the mask with the index finger over the chin part. Use your third, fourth, and fifth fingers to pull the chin upwards and backwards. Take a firm grip on, but never poke your fingers into, the patient's neck. Never push the mask down on the patient's chin as this may flex the neck and obstruct the air passage.
- While holding the mask with one hand (usually the left), squeeze the bag with the right hand about once every 5 seconds. The bag should be squeezed until the chest rises, then released to allow exhalation.
- If you hear leakage, hold the mask more tightly and squeeze the bag more forcefully.
- When the bag is released, the air inlet at the tail of the bag opens to allow it to refill. The valve at the mask prevents exhalation back into the bag. The bag should be released quickly to allow for prompt valve action.

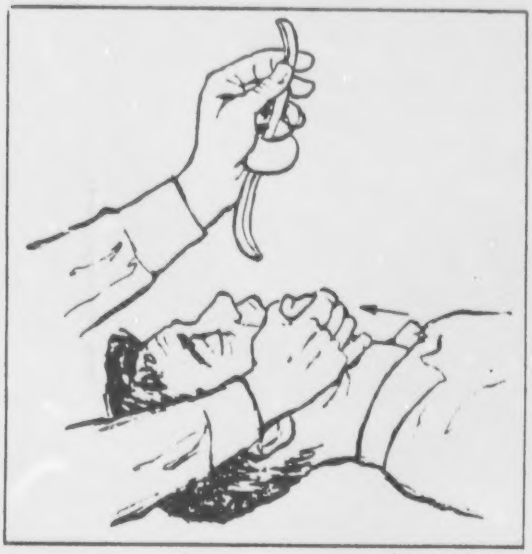

Figure 1-17. Inserting the airway

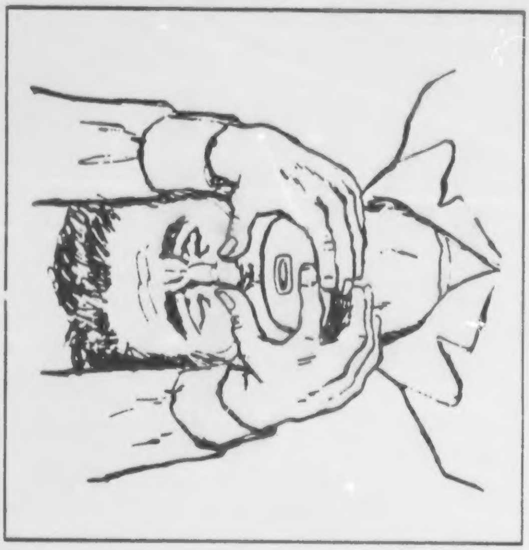

Figure 1-18. Positioning the airway.

REMEMBER: There are two important considerations when using a bag-mask resuscitator: (1) the airway must be open and (2) the mask must form a tight seal.

You must be especially watchful for signs of vomiting in the patient; and, if vomiting starts, discontinue the bag mask operation immediately. Continuing the operation will force vomitus into the patient's trachea, causing aspiration of the fluids into the lungs, or massive obstruction.

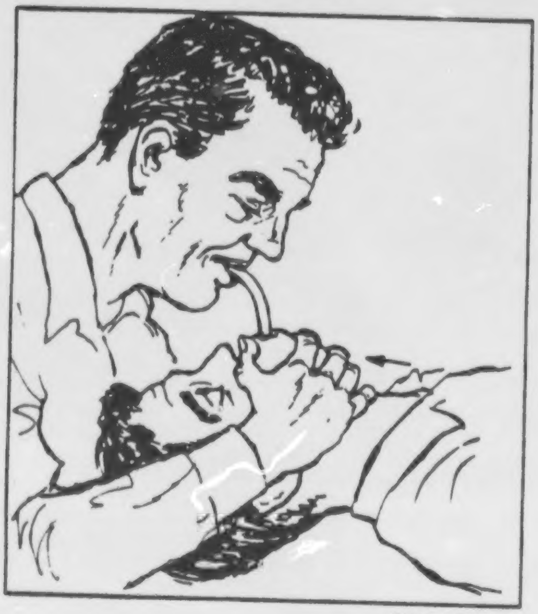

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Figure 1-19. Blowing into the airway.

Exercises (618):

1. Why have mouth facepiece units been introduced?

2. When an S-tube device is used for mouth-to-airway ventilation, how is air prevented from escaping?

3. What size breaths should be used when giving mouth-to-airway ventilation?

4. What is the most common problem encountered when a bag-mask resuscitator is used?

5. Explain how to ensure an adequate seal on a patient's face with a bag-mask resuscitator.

6. How often should the bag be squeezed when ventilating a patient?

7. What should you do if your hear leakage?

8. What must you be especially watchful for while using a bag-mask resuscitator? Why?

1-5. Checking Victims for Injuries

One of the more important tasks a first-aider will perform is that of checking victims for injuries. Care and caution must be used at all times. Failure to fully check a victim may result in missed minor injuries being made into major injuries through mishandling or wrong treatment.

619. Determine procedures for, and identify facts about, checking victims for injuries.

After the immediate problems are out of the way, you should thoroughly check the victim to determine the full extent of his injuries and the cause of the injury or sudden illness.

Protect the victim from unnecessary disturbance and/or manipulation—do not move the victim unless it is absolutely necessary. If the victim is exposed to dampness or cold, protect him with additional clothing and/or blankets, both over and under him.

Try to find out just what happened. Persons who saw or were present when the accident happened may be able to give you the information if the victim is not conscious. Look for medical identification such as a necklace, bracelet, card, or watch attachment. These MAY BE CLUES THAT give vital information. If possible, have a witness if you must search personal effects.

Examine Victim. The kind of sudden illness or accident should be a guide to you in your examination of the victim. Whatever you do, have a reason for doing it.

Clothing. Loosen tight or restrictive clothing. Do not pull on the individual's belt or waist band in case there are spinal injuries. If you must remove or open clothing to expose a part of the body for a more accurate examination, do so with the utmost discretion. Do not expose the victim unduly without protective cover.

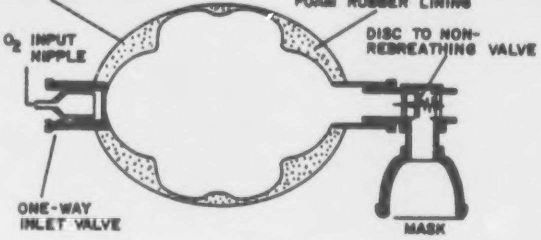

Figure 1-20. Bag-mask resuscitator (parts).

Appearance. The victim's general appearance should be noted. Check all symptoms that may give a clue as to the sudden illness or injury. Skin discoloration is very important. If the victim is dark skinned, the skin discoloration may be hard to detect. In these cases, it will be necessary to depend upon a change of color of the inner surfaces of the mouth, lips, or eyelids or mucous membrane.

Pulse. When checking a victim's pulse, try the wrist first. If you can't feel it there, then try the artery at the side of the neck. When taking a pulse, always use your fingertips rather than your thumb, because your thumb has a pulse of its own.

Consciousness. See if the victim is unconscious, awake, or stuperous. Does he respond to questions? Check for evidence of head injuries if the victim is unconscious. If the person is conscious, check for paralysis of one or both sides of the face or body. Also look for signs of recent convulsions.

Check the body. Check the size of the pupils of the victim's eyes and the expression of the eyes. Next, check the limbs and trunk of the body for fractures or wounds. If poisoning is suspect, check the victim's mouth for stains or burns. (Be sure to look around the area for a source of poison.)

While checking the victim, try to determine if he has identification stating that he cannot breathe through the nose or mouth (laryngectomy). If so, use caution while giving first aid not to block the air inlet (stoma). Death from asphyxiation could result from such blockage.

Upon completion of your check of the victim, you should take the necessary action to carry out the indicated first aid.

Exercises (619):

1. When should you check a victim for injuries?

2. Why do you check an accident or illness victim?

3. After a victim is in a safe area, when should he be moved?

4. When you are protecting an individual from cold or dampness, where should you place the protective coverings?

5. What should be your guide when examining a victim?

6. Why should you not pull on a victim's belt or waist band?

7. How can you determine skin discoloration if the victim is dark skinned?

8. What should you do if you cannot get a pulse from a victim's wrist?

9. How should you take a pulse?

10. What should you look for when checking the consciousness of a victim?

11. When checking a victim's eyes, what should you look for?

12. If you suspect poisoning when checking a victim, what should you look for?

1-6. Bandaging Principles and Techniques

During and after the control of bleeding, the wound must be protected from contamination. Often infection will set in during the healing process of the wound and cause prolonged suffering and serious, sometimes fatal, complications for the victim. The first-aider can prevent most of this contamination by applying a dressing and bandaging the wound properly. The following information is intended to assist you in performing this task.

First aid skills consist of "how" to perform certain activities, to use certain appliances necessary to make a victim comfortable, and to save a human life. First aid skills must be practiced regularly to maintain proficiency. A "one time through" course in performing first aid procedures does not in itself train a firefighter to be a proficient first-aider.

620. State the uses and applications of given dressings and bandages.

Gauze Squares. Gauze squares are made to cover wounds. They are made from many layers of folded gauze, and they may be purchased in many different sizes. To ensure their sterility, these squares are sealed in individual packages, and they will remain sterile until the seal is broken. Special care should be exercised when a gauze square is removed from an envelope to be placed over a wound. To remove a gauze square from its package, secure a small corner of the dressing between the thumb and index finger and pull it free. Do not touch or breathe on the side that is to be placed over the wound. After the dressing is placed over the wound, it may be held in place with the hand until it is secured by a bandage.

Adhesive Compress. An adhesive gauze compress consists of a pad of sterile gauze that has been placed in the middle of a strip of adhesive. These compresses are usually covered with a layer of crinoline to protect the adhesive. Adhesive compresses are available in various sizes for special purposes. The adhesive compress acts as both a dressing and a bandage for small cuts or scratches.

Bandage Compress. The bandage compress is made to be used for the same purpose as the adhesive compress, but it is larger. Instead of being held by adhesive tape, the compress is fastened in the middle of a long-tailed bandage. The common sizes are 2, 3, and 4 inches square. The bandage compress can be used for any surface it will cover.

Gauze Roller Bandage. Gauze roller bandages are rolls of sterilized cotton gauze. The most common widths are 1, 2, and 3 inches, and the length is usually 10 yards. The roller bandage is well adapted to the extremities, because it can be applied neatly and snugly on the irregular surfaces of these parts. If the roller bandage is applied too tightly, it will impede circulation. Adhesive tape can be used to hold the bandage in place, or the end can be cut lengthwise to make ties long enough to encircle the injured part.

Exercises (620):

1. What are gauze squares used for?

2. How should a gauze square be removed from its package to preserve its sterility?

3. What should be used for both a dressing and bandage for small cuts and scratches?

4. What is a bandage compress used for? How is it secured?

5. Why are gauze roller bandages well suited for use on the extremities?

6. What will happen if a gauze roller bandage is applied too tight?

621. List the steps for folding a triangular bandage into a cravat and state how a cravat is applied to given parts of the body.

Triangular Bandage Folded as a Cravat. The cravat bandage may be made into various widths from a triangular bandage. In order to form a cravat, bring the apex to the center of the base side and continue to fold from the apex side toward the base until the desired width cravat is obtained. For best results, it is best to fold the triangular bandage on a flat surface. Narrow cravats are most suitable for tying body extremities to splints. Wider cravats are used for body support and arm slings. The folds for a triangular bandage into a cravat are shown in figure 1-21.

Cravat bandage for palm of hand. Use a rather narrow cravat bandage and lay the middle across the palm with the thumb on top. (See fig. 1-22A.) Bring the end from the thumb side down and diagonally across the back of the hand, then fold back from the heel of the hand diagonally across the palm (B). Bring the other end around the back of the hand to the base of the thumb, fold up and over the thumb and across the palm, to the little finger side (C). With the same end, fold downward and across the back of the hand and bring up through the crotch of the thumb (E). Bring both ends across the back of the hand, wrap them around the wrist and tie (D).

Cravat bandage for cheek or ear. The cravat bandage for this dressing should be wide, and the start should be made with the middle of the cravat over the compress covering the cheek or ear. Carry one end over the top of the head and the other end under the chin. Cross the ends on the opposite side. Bring the short end back around the forehead and the long end around the back of the head. Tie them over the compress.

Cravat bandage for the forehead or ear. The difference between the ear and the forehead dressing lies only in the place where the tie is made. A bandage compress should first be placed over the injury, using the tails of the compress to tie it into position. Place the center of a cravat bandage over the compress where it covers the wound, and carry the ends around the head to the opposite side. Cross these ends and bring them back to the starting point and tie.

Cravat bandage for the elbow or knee. If possible, bend the elbow or knee at a right angle (90°) before

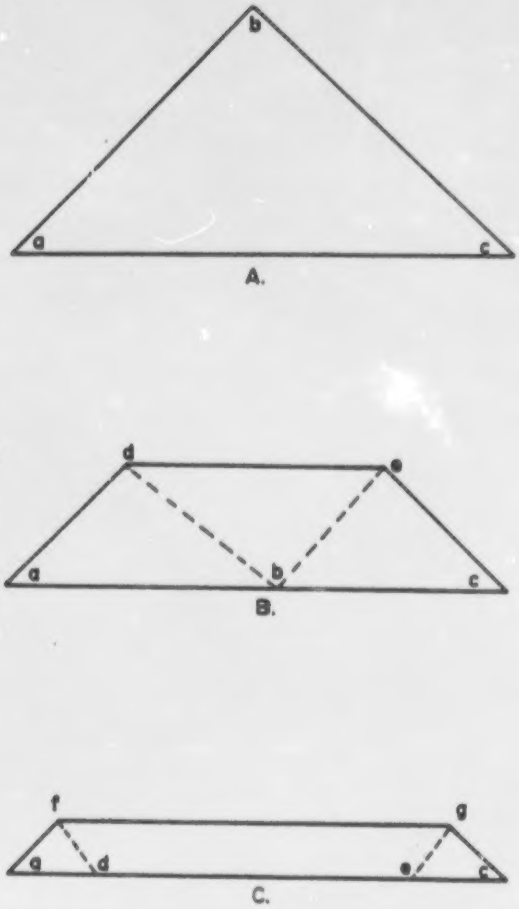

Figure 1-21. Folding a triangular bandage into a cravat.

the bandage is applied. A wide cravat should be used. Place the middle of the cravat over the elbow or knee and carry the ends around, crossing them in the hollow. Carry the upper end entirely around the arm or thigh above the elbow or knee, and bring it back to the hollow. Carry the lower end entirely around the forearm or leg below the elbow or knee, and bring it back to the hollow. Tie snugly at the outside edge of the hollow.

Exercises (621):

1. Explain how to fold a triangular bandage into a cravat.

2. What are wider cravats used for?

3. When a cravat is to be used for the palm of the hand, where is the middle of the cravat placed?

4. Where do the ends of a cravat cross when it is used as a bandage for the cheek or ear?

5. What is the difference between the ear and forehead dressing when a cravat is used for both?

6. At what angle should the joint be, if possible, when a cravat is applied to the knee or elbow?

7. After the ends of a cravat have been crossed in the hollow of the elbow, what is done with the upper end?

8. Where should the tie of the ends of a cravat be made when it is used on the knee?

622. State how to use a triangular bandage for given areas of the body.

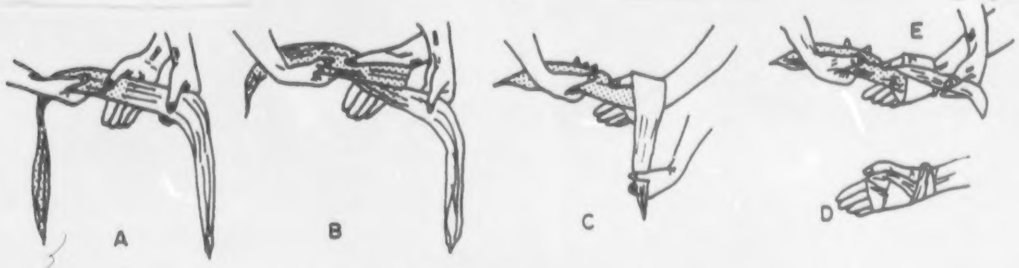

Figure 1-22. Cravat bandage for the palm of the hand.

Triangular Bandages. The triangular bandage is one of the most useful items available to you. It may be used in any number of ways for any number of reasons. One of the primary uses of a triangular bandage is to hold a compress in place. Given the choice of any single bandage/dressing in common use, you would be wise to choose the triangular bandage because of its versatility in use.

Arm sling. A good arm sling can be made from a triangular piece of cloth approximately 55 inches across the base and 36 to 40 inches along the sides. Regular triangular bandages of this size may also be purchased in unit packages.

Place one end of the bandage on the injured side, and let the other end hang down across the chest. Place the apex (point b in fig. 1-21A) behind the elbow of the injured arm. Carry the second end of the bandage up over the uninjured shoulder, and tie the two ends together at the back of the neck. Hold the bandage snugly at the hand, and pull on the apex to straighten the sling. The apex can then be folded forward and pinned to the front of the sling. If a pin is not available, twist the point of the apex until it is snug at the elbow, and tuck the twist between the arm and the sling. The ends of the fingers should extend just beyond the base of the sling. This permits one to observe whether or not the circulation is cut off. In all cases of injury to the hand or forearm, the sling should be adjusted so that the hand is elevated 2 or 3 inches above the level of the elbow.

Hand or foot. Spread the triangular bandage out wide, and place the hand so that the middle of the base of the bandage comes well up the wrist. Fold the apex of the bandage back over the back of the hand so that the point will come up on the wrist or forearm. Carry each of the other two corners back toward the wrist and over the hand to take up slack and make a smoother bandage. Cross the ends around the wrist, tie them, and tuck them under.

Head. Fold a hem about 2 inches wide along the base of a triangular bandage. With the hem fold on the inside, place the middle of this hem over the compress, and permit the bandage to cover the head with the apex pointing down the back. Carry the two ends around the head above the ears, and cross them just below the bump at the back of the head. Draw the ends snugly, carry them around the head, and tie them in the center of the compress. Steady the head with one hand; with the other, draw the apex down firmly behind to hold the compress securely against the head. Turn the apex up, and tuck it in where the bandage crosses.

Chest or back. Place the apex of a triangular bandage over the shoulder on the injured side. Carry the bandage down over the chest (or back) so that the center of the base is directly below the shoulder. Roll or fold the base as far up as you desire, carry the two ends around the body, and tie them directly below the apex. This procedure leaves one long and one short end. Tie the long end to the apex where it lies over the shoulder.

Face and/or back of the head. Tie a knot about 6 inches from the apex of a triangular bandage. Place the knot at the crown of the head, and carry the base down over the face and chin to the neck. Bring both ends around to the back, covering the cheeks, ears, and back of the head and neck. Cross them over each other, bring them back to the front, and tie them under the chin. Cut a slit for the nose and eyes, if they are not injured. The same bandage may be used to cover injuries to the back of the head, leaving the face exposed.

Shoulder or hip. Two triangular bandages are required for this dressing. Fold one triangular bandage into a narrow cravat (fig. 1-21), and leave the other one open. Roll the apex of the unfolded triangular bandage several turns around the folded cravat, and lay it with the middle of the folded cravat over the injured shoulder. Carry the ends of the folded cravat around the body below the opposite armpit, and tie it slightly forward from the armpit. Bring the open triangular bandage down over the dressing so that the base of the bandage lies on the arm. Fold the bandage up the arm as far as desired. Cross the ends around the arm and tie them snugly, but not too tight. Check the amount of pressure by feeling the pulse at the wrist on the injured side to make sure circulation has not been shut off. The same procedure may be used for bandaging the hip.

Exercises (622):

1. When a triangular bandage is used as an arm sling, where should the apex of the bandage be placed?

2. Why should the ends of the fingers extend just beyond the base of the sling?

3. The sling should be adjusted so that the hand is in what position?

4. When using a triangular bandage for the hand, where should the hand be placed in relation to the middle of the bandage?

5. How is the bandage secured when used on the hand?

6. Where should the bandage ends cross when used for an injury to the forehead?

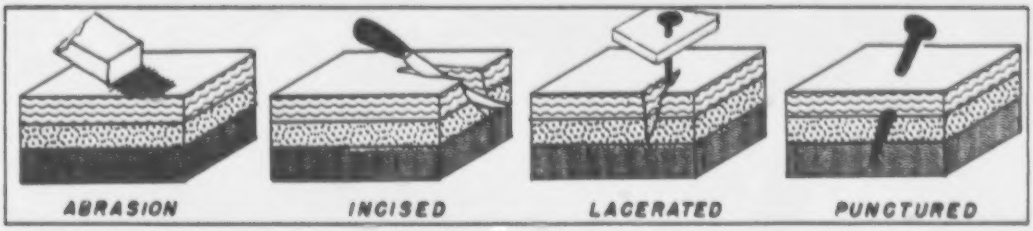

Figure 1-23. Types of open wounds.

7. After the bandage has been pulled down snug on a head wound, what is done with the apex of the bandage?

8. How is the bandage positioned when used for the back or chest?

9. Explain how to apply a triangular bandage to cover the back of the head.

10. When triangular bandages are used for the shoulder, where is the cravat folded bandage located?

11. Where is the open triangular bandage secured for the shoulder application?

1-7. Wounds

A good bit of your work in first aid will involve various types of wounds. For this reason, you should know what the various types of wounds are and how they may be caused.

623. Identify types of open wounds; state the characteristics of given open wounds and the proper treatment of them.

Wounds are injuries to the soft tissues of the body and are classified as open or closed. Where the skin is broken and underlying tissues are exposed, it is an open wound. When the skin is unbroken and injuries to the underlying tissue have occurred, it's called a closed wound. Bleeding may vary from slight to profuse. (See fig. 1-23.)

Abrasion. An abrasion is the least serious type of open wound. It is little more than scratching of the skin surface, without penetration of all layers of the skin. Contamination should be considered even though the wound may appear very minor.

Incision. An incision is a wound usually made by a sharp object. The edges of the skin and underlying tissues are smooth because of the sharpness of the object inflicting the injury. Because blood vessels have been cut cleanly, incisions bleed freely. The difficulty of controlling the bleeding depends on the depth of the incision and the vessels that have been cut.

Laceration. A laceration results from the tearing or snagging of the tissues which leaves a jagged wound that bleeds freely. This is one of the most dreaded types of wounds because of the stretching and tearing of the blood vessels and the possibility of severe bleeding.

Puncture. A puncture wound results from the disruption of the skin and underlying tissue by a sharp, pointed object, such as a nail, ice pick, or other pointed object. Usually, severe bleeding does not accompany this type injury. Puncture wounds are classed as penetrating or perforating.

Penetration. A penetration is a wound, either shallow or deep, that damages tissue and blood vessels. It may result from such a thing as a knife blade, a wide metal strip, or a long, pointed shread of glass.

Perforation. A perforation is a deep puncture wound, such as a through-and-through gunshot wound passing through nerves, bones, and organs, and causing great internal damage. This wound has an exit which is different from a penetration wound.

Avulsions. Avulsions, or wounds where large flaps of skin and tissue are torn loose or pulled off, are characteristic of industrial accidents. In an accident that results in an avulsion, you should make every effort to preserve the avulsed part and transport it to the hospital with the victim.

Traumatic Amputations. Traumatic amputations involving the fingers, hands, arms, and legs generally occur when the extremity is torn off in an accident. Jagged skin and bone edges characterize the wound, and there may or may not be massive bleeding. As for other external bleeding, the most effective method of control is to use a snug pressure dressing over the stump. A tourniquet will rarely be necessary.

Crushing Injuries. Crushing injuries are caused by mechanisms in which the extremities of the body are caught. In these accidents, open fractures are common, and there is usually a surface laceration of the bursting type with extensive damage to the underlying tissues. Large, bulky dressings are required for emergency care. In cases where a limb has been severed by an extremely heavy force, such as a train, there will probably will be very little bleeding, since there is a strong tendency for the crushing action to close off the bleeding vessels effectively as they are severed.

Exercises (623):

1. What type of wound is made with a sharp object which leaves the edges of the skin smooth?
2. What determines the difficulty of controlling the bleeding from an incision?
3. What type of wound bleeds freely and leaves a jagged edge as a result of tearing and snagging of the tissues?
4. Why is the laceration one of the most dreaded types of wounds?
5. What is a puncture wound?
6. What are the classes of puncture wounds?
7. In which class of puncture would you find an exit wound which is different from the puncture?
8. What should be done with the avulsed part should an avulsion occur?
9. What is the most effective method of controlling the bleeding from the stump should a traumatic amputation occur?
10. Why would there probably be little bleeding if a limb has been severed by a heavy force, such as a train?

624. Specify the causes and effects of closed wounds, impaled objects, and nosebleeds and the first aid recommended for them.

Types of Closed Wounds. The resulting injury from the impact of a blunt object is called a bruise or contusion. Although the skin is not penetrated, there may be a great deal of crushed tissue beneath. There is always a variable amount of bleeding which takes place at the time of the injury and frequently for a few hours thereafter. Swelling generally develops 24 to 48 hours after the injury occurs. A blood clot almost always forms at the injury site, with the blood seeping into the surrounding tissues, causing a bluish discoloration, or "black and blue" mark.

Small contusions, unless they are associated with more serious problems, such as internal injuries or fractures, generally do not require emergency care. A pressure dressing will reduce bleeding and assist the natural healing process.

Impaled Object. Occasionally, you will be confronted with a wound from which a pointed object, such as a knife, a stick, or a piece of glass, is protruding. This type of wound is called an impaled object wound. The following rules should be strictly complied with:

- Do not remove the object.
- Use a bulky dressing to stabilize the object.
- Transport the patient to a hospital very carefully.

If the impaled object is removed, it may cause further damage to the nerves and muscles, or it may cause a severe hemorrhage by releasing the pressure on the severed blood vessels.

The only exceptions to the rule of leaving an impaled foreign object in place occurs when the object is impaled in the cheek and interferes with the patient's breathing or when the consequent bleeding cannot be controlled with the object in place. The other time when you may be required to remove an impaled object is when a knife, arrow, or the like is impaled in the chest and the victim is in cardiac arrest. In this case, you must perform cardiopulmonary resuscitation. If the impaled object prevents this, or is in a position to lacerate the heart or other vital organs when compression is accomplished, then it must be removed to save the victim's life. Extreme caution must be exercised when removing an impaled object.

The first aid for an impaled object is basically to stabilize it with large bulky dressings. UNDER NO CIRCUMSTANCES SHOULD YOU LET THE OBJECT MOVE AROUND.

Nosebleed. Nosebleed may be caused by high blood pressure, activity, colds, exposure, or high altitudes. The bleeding is usually more annoying than serious; but occasionally, with underlying disease, the bleeding is profuse, prolonged, and dangerous. A victim of nosebleed should remain quiet. A sitting position with the head and shoulders raised is best. Walking about, talking, swallowing, laughing, or blowing the nose may cause increased bleeding or resumption of bleeding. The bleeding area is usually near the tip of the nose, and pinching the nostrils together may stop the bleeding. It may be necessary to pack the bleeding nostril lightly and then pinch. Placing the victim in the supine position and applying cold, wet towels will frequently permit a clot to form in the nasal space. If the bleeding is profuse, pinching the nose may only cause the blood to flow down the esophagus. Remember that a small child or infant has very little blood to lose. If one of the methods above does not check the bleeding, place a gauze (or similar material) approximately one-half inch thick between the upper lip and upper teeth as far as possible, then place your finger above upper lip and apply digital pressure.

Exercises (624):

1. What causes a bruise or contusion?

2. If swelling occurs as a result of an injury, it will generally develop within how many hours of the injury?

3. What causes the "black and blue" mark associated with a bruise?

4. What type of dressing should be used to reduce bleeding and assist the natural healing process when a small contusion is encountered?

5. What may happen if an impaled object is removed when the removal is not necessary?

6. When should an impaled object be removed?

7. What is the first aid for an impaled object?

8. What is the best position in which to place a patient with a nosebleed?

9. What should you do to permit a clot to form in the nasal space?

10. If, as a last resort, you must place a gauze pack between the patient's upper lip and teeth, how thick should the pack be?

625. Specify the causes and effects of wounds to the chest and the first aid recommended for them.

Accidents in which the victim is thrown against a sharp-pointed object, in which the chest cavity is penetrated by a bullet or other missile, or in which the chest is pierced by a knife may produce what is known as a "sucking" chest wound. However, sucking wounds usually occur only in the case of violent injury such as a shotgun wound to the rib cage; a knife or small caliber bullet is likely to seal itself in the muscles of the chest area.

Air entering or being expelled from the wound creates a characteristic "sucking" sound, which may be accompanied by a loud "grunt" as the victim makes a desperate attempt to breathe. He is unable to fill his lungs with air, and severe respiratory difficulty results. All penetrating wounds of the chest should be considered to be sucking wounds and treated as such.

Pneumothorax. Pneumothorax occurs when the pleural sac (sack surrounding the lungs) is opened by a missile, knife, or other foreign object and outside air is admitted to the chest cavity. Since lung action depends on the negative pressure that develops in the pleural sac as the chest wall expands in normal breathing, any opening in the sac results in the loss of function. The two walls of the pleural sac cannot operate together due to the air in the sac, and the lung on the injured side collapses. The collapsed lung is pushed over toward the good lung as the patient breathes in, thus interfering with its efficiency. As the patient exhales, there is a shift in direction by the collapsed lung, and air is expelled from the wound. The collapsed lung has a tendency to interfere with the operation of the heart, reducing its efficiency.

The major sign of pneumothorax is the hole in the chest wall itself, or an impaled object extending from the chest. If the lung has been penetrated along with the chest wall, the patient will be spitting up or coughing up bright red, frothy blood.

First aid for a victim with a pneumothorax condition is to seal the hole in the chest to prevent breathing through the hole. The hole should be sealed immediately with aluminum foil, or ordinary household wrap. Hold the seal in place with tape making sure that all edges are tightly sealed. Lacking any other method, hold the palm of your hand directly over the wound. When a sealing dressing is in place, transport the victim on the injured side, provided there is no impaled object.

Tension Pneumothorax. Pneumothorax limited to one side of the chest may cause respiratory difficulty, but it will probably not cause the death of the victim unless a condition known as tension pneumothorax develops. With tension pneumothorax, air pressure within the chest cavity builds up to such a degree that the collapsed lung is pressed against the uninjured lung and the heart, interfering both with ventilation of the good lung and with heart action.

If the injury to the chest was sufficient to produce a sucking chest wound, but did not puncture the lung, then the sealing action described for a sucking chest wound is an effective emergency measure. if there is no lung injury and the hole is effectively sealed, there is no opportunity for tension pneumothorax to develop. However, if the lung was punctured at the time of the injury to the chest wall, tension pneumothorax could develop after the chest wall is sealed. This will be indicated by the steady decline in the victim's condition despite resuscitative efforts.

NOTE: If you see the patient worsening for no apparent reason, unplug the seal immediately. If there is tension pneumothorax, there will be an escape of air. the victim will improve almost immediately as the pressure is released from the uninjured lung and heart.

The real difficulty in treating tension pneumothorax occurs when there is no sucking sound. This is done by a broken rib, or the lung "blows" out due to natural causes. In this instance, when the lung blows out, it is called a spontaneous pneumothorax. All you can do is transport the patient immediately to a hospital.

Exercises (625):

1. How does an opening in the pleural sac affect the function of the lungs?

2. What happens to the lung on the injured side when outside air enters the sac through a wound?

3. How does a collapsed lung affect the other lung?

4. How can you tell if the lung has been penetrated along with the chest wall?

5. What is the first aid treatment for a victim with a pneumothorax condition?

6. If there is no impaled object involved, how should a patient with a pneumothorax condition be transported?

7. How does tension pneumothorax cause interference with the good lung and the heart?

8. What can you do for a patient who suffers from lung "blow out" due to natural causes.

1-8. Fractures and Splints

Since fractures are one of the most common injuries encountered, you must be able to identify the fracture and give the proper treatment. Remember, your primary mission as a first-aider is to reduce pain and prevent further injury. To attempt to move or transport a victim with a broken bone without first immobilizing it would almost certainly mean further injury. You must keep the broken ends of the bone still, and to accomplish this you must immobilize. In many cases, if the bone is properly splinted, the pain will be reduced to a tolerable level and will be much appreciated by the victim. Remember, a fracture is very painful and quite disgusting looking. The victim can be in shock and extreme pain.

The traditional complement of bones in each human being is 206, but this is a general rule, not a law. About one person in 20, for example, has a 13th pair of ribs, and mongoloids frequently have only 11 pairs. A baby is born with about 350 bones, some of which fuse in later life, and some of which retain their individual identity throughout life. All bone fusion is over by the end of the growth period. (See fig. 1-13.)

If and when any of the bones are broken, they must be immobilized before the patient is moved.

626. Identify fractures by their classes and types and state first aid for them.

The signs and symptoms of fractures vary. Deformity, grating, swelling, discoloration, and the loss of use are the most visible signs of a fracture. The patient's information is usually accurate as to the location of a broken bone.

When accidents are such that a fracture could exist, you should assume that it does exist and treat the patient accordingly.

If you are to treat the patient for fractures, there are a few simple rules to remember. If the patient's condition is stable, he will tell you of the fracture and its location. Do not push back any bone ends; splint the extremity, immobilize the joints above and below the fracture, apply traction during splinting, and splint firmly.

Severely angulated fractures pose a problem for both you and the patient. The acute angle may be pinching or cutting nerves and blood vessels at the injury sites. You should attempt to straighten severely angulated fractures of the upper and lower extremities by applying traction. DO NOT ATTEMPT TO STRAIGHTEN FRACTURES OF THE JOINTS.

The steps to take when straightening angulated fractures are: gently grasp the extremity above and below the break, apply traction steadily and smoothly, and maintain traction while the splint is being applied. This requires at least two persons.

Classes of Fractures. From a first-aider's point of view, there are two classes of fractures: the open type and the closed type. (See fig. 1-24.)

Open fracture. The open fracture is one of the easiest for you to locate. This fracture is where an open wound is associated with a fracture.

Closed fracture. The closed fracture is one in which the bone may be cracked and there is no associated open wound.

The two classes of fractures are then categorized as "types of fractures" according to the way the bone is broken. Following are seven types of fractures. (See fig. 1-25.)

(1) Transverse—break straight across the bone.

(2) Oblique—break at an angle to the bone.

(3) Spiral—break twists around the shaft of the bone.

(4) Greenstick—break split along the length of the bone.

(5) Comminuted—bone is fragmented instead of broken.

(6) Impacted—bones are broken, then jammed into each other.

(7) Overriding—broken bone ends slip past each other.

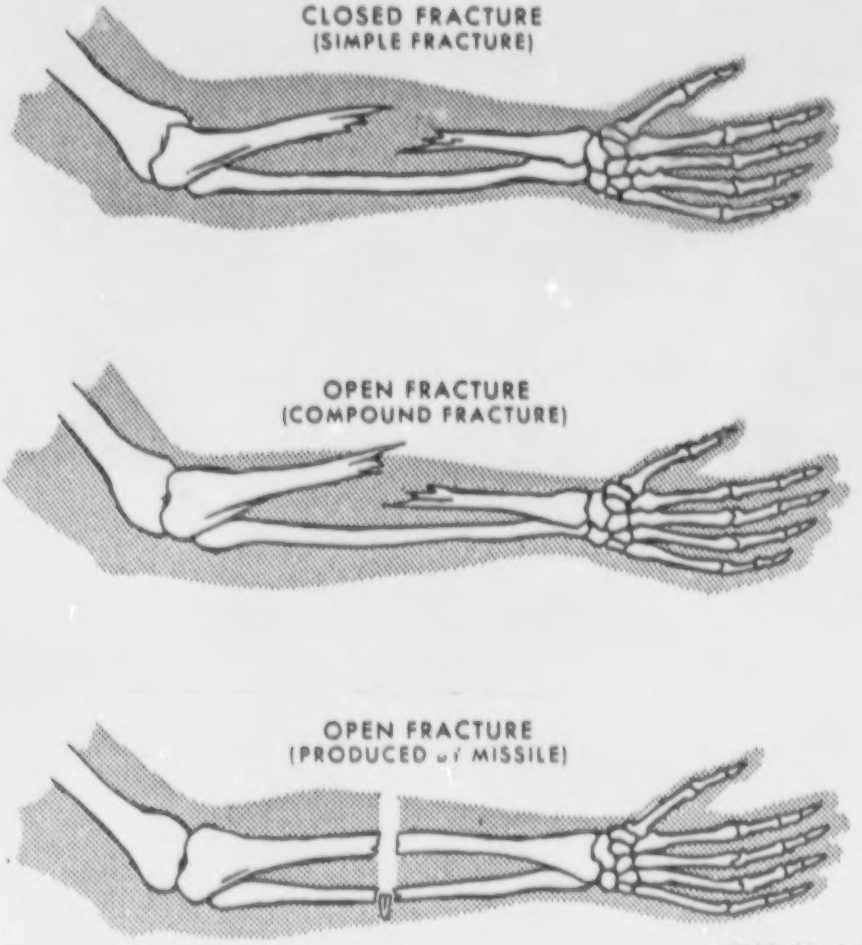

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Figure 1-24. Classes of fractures.

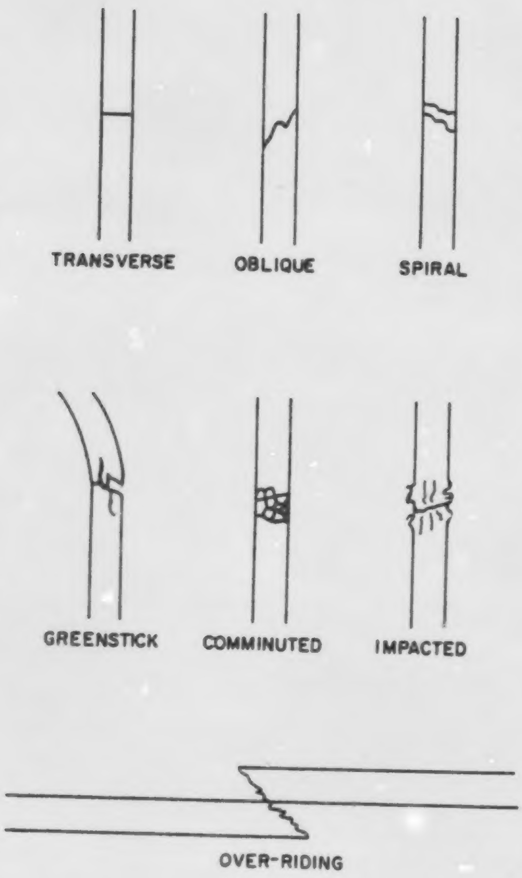

Figure 1-25. Types of fractures.

Exercises (626):

1. What parts should be immobilized when splinting a fracture?

2. What are the two classes of fractures?

3. The two classes of fractures are categorized as types of fractures according to what?

4. A fracture at an angle to the bone is known as an ________ fracture.

5. What is a greenstick fracture?

6. Describe an impacted fracture.

627. Identify types of splints and state their uses.

Types of Splints. Any material or appliance that can be used to immobilize a fracture or dislocation is known as a splint. There are many types of commercially made splints, such as wooden splints, scored cardboard splints, molded aluminum splints, soft wire splints, and inflatable splints.

In addition, many rescue vehicles are equipped with homemade devices, such as long and short backboards, padded boards, long and short notched boards, and traction devices. However, the lack of a commercially made or specially prepared splint SHOULD NOT deter you from immobilizing a fracture or dislocation. A piece of wire or a tongue depressor incorporated in a bandage may be sufficient to immobilize a fractured finger. An injured leg may be adequately immobilized by bandaging it to the good leg (fig. 1-26), or by binding it in a pillow or a blanket roll. A cane, umbrella, baseball bat, or similar object may be used to splint a broken arm. Rolled up newspapers also make good splints. A door or a ladder may be used as a stretcher for transporting a victim with an injured back or spinal injury.

Splints are of two basic types, rigid and traction. The general rules for use of these splints are as follows. Backboards, notched boards, molded splints, cardboard splints, and inflatable splints are all examples of rigid splints. A rigid splint, whatever its construction, must be long enough so that it can be secured well above and below the fracture site to include the joints, immobilizing the entire bone.

Inflatable splints provide an effective means of immobilizing fractures of the lower leg or the forearm. They are of little value for fractures of the humerus or the femur, since they do not extend past the upper joint in either case.

When an inflatable splint is applied in cold weather and the patient is moved to a warmer area, the air in the splint will expand, and dangerous pressure may be generated. It may be necessary to deflate the splint until the proper pressure is reached.

If the splint is of the zipper type, it is necessary to lay the limb in the unzipped splint and then to zip it up and inflate it. It may not be possible to maintain traction on the injured limb during the operation.

Remember, an air splint should be inflated only by mouth and only to the point at which an indentation in the splint can be made easily with your thumb.

You should be very careful whenever you are applying splints. When splints are applied correctly, they do the following:

- Reduce the possibility that a closed fracture will become an open one.

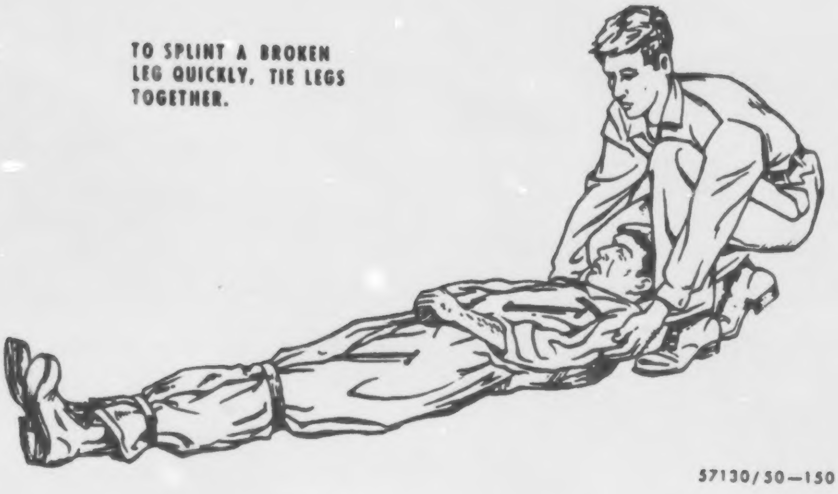
TO SPLINT A BROKEN LEG QUICKLY, TIE LEGS TOGETHER.
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Figure 1-26. Quick splinting of a broken leg.

- Minimize the damage to nerves, muscles, and blood vessels that might otherwise be caused by the broken ends.
- Prevent the broken bones from churning around in the lacerated tissues and causing more bleeding.
- Lessen the pain that is normally associated with the unrestricted movement of broken bone ends.

Broken bones, especially the long bones of the arms and legs, often have sharp, sawtooth edges. Slight movement may cause the sharp edges to cut into blood vessels, nerves, or muscles, and perhaps through the skin. Therefore, by careless or improper handling, a simple fracture can be converted into a compound fracture. Damage due to careless handling of a simple fracture may greatly increase pain and shock, cause complications that will prolong the period of disability, and endanger life through hemorrhage of pierced blood vessels. The general symptoms of fractures are: (1) pain in the region of the fracture; (2) loss of function in the case of long bones; (3) deformity or irregularity of the part; (4) moderate or severe swelling; and (5) in fractures of the extremities, the limbs are usually shortened.

Be careful when examining injured persons, particularly those apparently suffering fractures. Do not attempt to change the position of an injured person until a careful examination has been made. If a person is lying down, it is far better to dress the injuries in that position with as little movement as possible. If fractures are present, make any necessary movement in a manner to protect the injured part against further injury.

In fractures of the extremities, place a constriction band loosely above the fracture as a precaution in case it is needed. Cautiously place the limb in as nearly a natural position as possible by grasping its lower part well below the fracture, but not pulling on the limb, while an assistant supports the under part of the limb on either side of the break. Then apply appropriate padded splints, being sure to place extra padding under all hollow spaces, such as knee, ankle, or wrist. Support all fractures except those of the skull, nose, upper and lower jaw, cheekbone, shoulder blade, and ribs until dressings have been applied.

Exercises (627):

1. What is a splint?

2. What are the two basic types of splints?

3. How long must a splint be to be a rigid splint?

4. Why are inflatable splints of little value for fractures of the humerus or the femur?

5. How should an air splint be inflated?

6. How can you tell when an air splint is properly inflated?

1-9. Poisonings

Each year in the United States, approximately one million cases of poisoning occur. About 10,000 of these cases are fatal. While many cases of poisoning are suicidal, many others are accidental, involving substances in everyday use such as medicines, cosmetics, cleaning agents, and plant and insect sprays.

628. Given symptoms of poisoning, state the way in which the poison entered the body.

Poisons enter the system in four ways:

- Ingestion (by mouth).
- Inhalation (by nose).
- Absorption (through the skin).
- Injection (into the body tissues or bloodstream).

Symptoms. The symptoms of poisoning vary with the nature of the poison and the route by which it enters the body. With many poisons, acute symptoms may be delayed for several hours. Some of the major symptoms of poisoning are as follows.

Ingested poison. When poison is ingested by an individual, he may show signs of poisoning by nausea, vomiting, diarrhea, severe abdominal pains and/or cramps, and slowed respiration and circulation.

Inhaled poison. Respiratory problems such as shortness of breath, coughing, and cyanosis are symptoms of inhaled poisons, and the patient may go into cardiac arrest.

Absorbed poison. Poison absorbed by an individual may be indicated by irritation of the skin and mucous membranes and inflammation of the eyes.

Injected poison. The symptoms of injected poisons include swelling, tenderness, and pain at the site of the injection as well as depression or failure of the respiratory and circulatory systems.

In addition to the above, other symptoms may be present, such as the telltale bottle, burn tracks of acid, discoloration of the lips and tongue, and in some cases an odor.

Exercises (628):

1. When an individual that has been poisoned has severe abdominal pains, cramps, nausea and diarrhea, the poison most likely was ________ .

2. Cyanosis, coughing, and shortness of breath are indications of poison entering the body by being ________ .

3. Irritation of the skin and inflammation of the eyes are indications that poison has been ________ .

4. Swelling and tenderness, or failure of the respiratory and circulatory systems, indicate that poison has been ________ .

629. Specify first aid for someone who has ingested, inhaled, or absorbed poisons.

Emergency First Aid for Ingested Poisons. Since poison, like food, stays in the stomach for only a short time before it is absorbed into the system, it is vital that the poison be removed as soon as possible. One of the quickest ways is by vomiting. In most cases this can be done very quickly and safely, but in others VOMITING CAN CAUSE FURTHER DAMAGE. Causing a victim to vomit is NOT recommended in the following cases:

- If the victim has swallowed a strong acid or alkali. This would cause further damage to the throat and esophagus as it comes back up.
- If the victim has swallowed a petroleum product. This might cause a serious form of penumonia if aspirated.
- If the victim is unconscious or semiconscious. This might cause the victim to aspirate.
- If the victim is convulsing or has convulsed. The convulsions may continue if vomiting is induced.
- If the victim has a serious heart condition. The heart condition will be aggravated by the strain of vomiting.

In any case, the poison must be diluted immediately. Administer large amounts of milk, milk of magnesia, water, or a mixture of these. Administer as much as the victim will take, then (except in the above mentioned cases) induce vomiting by tickling the back of the throat with a finger or blunt object.

Keep the victim's head as low as possible to prevent aspiration of vomitus into the lungs.

Collect the vomitus and take it to the hospital with the patient so that it may be examined for poisonous substances. If the poison container can be found, it should be transported to the hospital with the victim. Also check the container for the antidote.

Emergency First Aid for Inhaled Poisons. The first step in the treatment of a victim of inhaled poison is to remove the victim to a safe area out of the contaminated area. If necessary, perform CPR.

One of the inhaled poisons most commonly encountered is carbon monoxide. Carbon monoxide has a peculiar effect on the body that makes it an especially dangerous poison. While normally the red blood cells pick up oxygen easily in the lungs, carbon monoxide unites with the red blood cells 250 times as readily as oxygen. Thus the oxygen-carrying capacity of the blood is reduced, the brain suffers from the lack of oxygen, and death occurs, even after only a short exposure. Fortunately, the process can easily be reversed if the patient is treated before the red blood cells have absorbed any great amount of carbon monoxide and if the gas can be readily removed from the lungs.

Usually there is no indication of carbon monoxide poisoning until the victim collapses, especially in cases where a muffler leak allows carbon monoxide to enter an automobile. The gas is odorless, tasteless, and colorless, so the dangerous accumulation is not recognized until the driver passes out. He may have headaches and dizziness, but these are usually attributed to other causes and thus overlooked. There is only one sign of carbon monoxide poisoning that is usually reliable and unmistakable: the skin takes on a cherry-red color that is unlike any other symptom of illness.

To care for a patient suffering from carbon monoxide poisoning, remove him to fresh air and start oxygen inhalation immediately, preferably with a bag-mask resuscitator, so that oxygen administration is as effective as possible. If the patient is breathing spontaneously, a mechanical inhalator may be used. Transport the patient to the hospital as quickly as possible.

Emergency First Aid for Absorbed Poisons. Any time the skin is contacted by a substance that is capable of poisoning through the skin, the most important step in the treatment is FLUSH WITH WATER. Water is the most readily available agent and will usually remove the substance. You may use soap if necessary. Flush the affected area for at least 15 minutes. Do not use any medication on the skin unless directed to do so by a doctor. If the substance contacts the eyes, flush immediately and for at least 15 minutes. The victim should be held under a water faucet or the eyes submerged in a basin of water with the eyelids in a fluttering motion if possible.

Exercises (629):

1. Vomiting should not be induced if the victim has ingested what types of poison?

2. What should be used to dilute ingested poison?

3. What should be transported to the hospital along with the patient?

4. Why is carbon monoxide so dangerous?

5. What is the only sign that is reliable and unmistakable in carbon monoxide poisoning?

6. What is the treatment for carbon monoxide poisoning?

7. What is the most important step in the treatment of poisoning by absorption?

8. How long should the eyes be flushed if a poison contacts them?

630. Specify the recommended treatment for snakebites and other injected poisons.

If poison has been injected into the blood stream, the first item of business is to block the flow of the poison to the heart. This is done by the application of a constriction band. In some cases, a bee sting, a spider bite, or certain other injections will cause anaphylactic shock.

Snakebites. The one major difference between snakebites and other injected poisons is the time element. In most injected poisonings, time is vital but, in the case of snakebite, you will usually have a lot more time to work with.

Although the chance of base personnel being bitten by a snake is very slim, the fact is there are many victims of snakebite in the Air Force each year. This necessitates knowledge of the identification, care, and transportation of the victim of snakebite.

The four kinds of poisonous snakes in the United States are rattlesnakes, copperheads, cottonmouth moccasins, and coral snakes. Most snakebite fatalities in this country are caused by rattlesnakes; they inject much venom if they are large and if they have not discharged their supply recently. They are identified by their rattles. A copperhead has a general pattern of copperish, chestnut, or dark brown colors on a lighter background color. Cottonmouth moccasins are heavy-bodied and are dark olive or brown in color. When this snake is annoyed, it draws its head back and opens its mouth, exposing cotton-white mouth tissues, for which it is named. The coral snake, found along the coast and lowlands of the southeast, is small; it chews rather than bites and cannot readily attach to large surfaces. Its potent venom affects the nervous system. The fatality rate from untreated poisonous snakebites probably is between 10 and 15 percent.

If a person intends to go into a snake-infested country, he should watch where he steps, places his hands, and sits. He should wear high boots or stout leggings, because over half of all bites are below midcalf. He should exercise extreme care when picking berries and flowers and when climbing ledges.

Symptoms. Pain is immediate if the snake is poisonous. The poisoned part soon swells and discoloration appears. Coral snake venom causes only slight burning pain and mild swelling at the wound. The bite of a nonvenomous snake gives little pain and produces little swelling. Poisonous snakes inflict one or two puncture wounds, and they may introduce tetanus germs as well as venom. The absorption of the poison causes weakness, shortness of breath, nausea, and vomiting; a weak and rapid pulse; and sometimes dimness of vision. Unconsciousness may occur. If the poison was injected directly into the bloodstream, these signs appear quickly. Otherwise absorption is slower, and reactions may become marked only after an hour or two.

First aid for victim of coral snake. This little fellow is the only snake in the United States in the neurotoxic group (affects the nervous system). They are nonaggressive and almost have to be forced to bite. They chew their venom into the tissues of their victims because they have no fangs. They are easy to recognize by their bright red, yellow, and black bands. There is no known treatment for coral snakebite. In any case, do not stimulate your circulation by running about or other activity if you form a first-hand acquaintance with one.

First aid for victims of rattlesnake, copperhead, and cottonmouth. Have the victim stop all muscular activity at once. Tie a constriction band firmly above the bite if it is on an extremity. This band should be tight enough to prevent the flow of blood in the surface vessels, but not enough to shut off the deep-lying vessels. If the band is properly adjusted, there will be some oozing from the wound.

Sterilize a knife blade, or use the blade in a snakebite kit, and make incisions. Try to cut into the venom deposit point, remembering that a snake strikes downward and its fangs retract. Make a cut only through each fang mark, about 1/8-inch to 1/4-inch long and about 1/8-inch to 1/4-inch deep. Muscles and nerves run in a longitudinal direction and deep crosscuts may sever them. Avoid cutting muscles, tendons, and nerves of the fingers, hands, or wrist, for their injury may cause disability.

Apply suction, using the mouth or suction cup. Venom is not a stomach poison, but it is advisable to rinse the fluid from the mouth. Some poison might be absorbed along an infected gum margin, but the effects would be mild and local. Continue suction at intervals for an hour or more.

Get medical care. If transportation is necessary, keep the victim lying down, with the injured part somewhat lower than the rest of the body. During relief-from-suction periods, apply cold packs, if possible, to the part involved. This treatment gives some relief from pain and may slow the absorption of poison into the system.

The circulatory control method is comparatively new treatment for snakebite. It can be used for all venomous bites and stings such as those from snakes, scorpions, Gila monsters, ants, bees, wasps, and spiders. Treatment should be started immediately. Keep the victim as inactive and quiet as possible. Tie a constriction band at once between the site of the bite and the heart, as close to the bitten area as possible. This prevents the poison from spreading through the body.

Place a piece of ice on the bite and prepare an ice bath for the bitten area of the body. Submerge the area into an ice and water bath above the point of the constriction band. If the bite is in an area where this cannot be done, pack the area with crushed ice. Ice bags will not be as effective.

After the hand, arm, foot, or other area has been in the ice bath for five minutes but not more than 10 minutes, remove the constriction band. Keep the bitten part in this ice bath for from 2 to 24 hours. Two hours is generally enough for a scorpion sting, 7 to 10 hours for a Gila monster bite, and 24 hours for a pit viper. After the prescribed time, allow the part to warm for 10 minutes. If the action of the poison is felt, continue treatment. If a body part is to be in the ice bath for more than 2 hours, it is well to protect it from the moisture by wrapping it in a plastic bag or plastic cover.

During this treatment, keep the person warm, almost to the perspiration point. Use blankets or artificial ventilation to achieve this purpose. After this treatment, allow the area to warm up slowly. Remove the ice supply and allow the water to warm to room temperature. Professional medical treatment should be provided as soon as possible.

Exercises (630):

1. What is the first thing that must be done if the poison has been injected into the bloodstream?

2. The venom from what kind of snake affects the nervous system?

3. Besides the venom, what may be introduced by a snakebite?

4. Explain how you would treat a bite by a rattlesnake.

1-10. Burns

Today's Air Force aircraft has such large amounts of fuel and so many people on board that there is always the possibility of burned crewmembers in any aircraft incident.

Burns are a leading cause of accidental deaths. If the accident is not fatal to the victim, he is often left permanently disabled or badly scarred. There is usually a need for prolonged hospitalization, close medical and nursing care, and restorative surgery following a severe burn.

631. Identify types of burns and specify treatment for them.

The first-aider should be concerned with making the burn victim as comfortable as possible and transporting him to medical facilities at once.

Types. There are three general types of burns a first-aider must be prepared to deal with: (1) thermal burns, (2) chemical burns, and (3) electrical burns.

Classes. Burns are classified according to the following methods:

First degree - the skin is reddened.

Second degree - partial thickness, blisters develop.

Third degree - full thickness, charring, deep destruction.

First degree burns are burns involving the outer layer of the skin. A first degree burn is a superficial injury, characterized by reddening of the skin. Second degree burns are burns involving a partial thickness of the skin. A second degree burn is characterized by deep reddening and blistering caused by the deep penetration of the injury. Third degree burns are burns involving all layers of the skin and sometimes the fat, muscle, and even bone. Third degree burns may be the least painful type of burn because of the massive damage to the nerve endings in the skin.

Thermal burns are those burns that are caused by direct flame or radiated heat. It is practically impossible to determine the degree of a burn soon after it has been inflicted because there may be different degree burns in different parts of the body surface. Third degree burns heal especially slow since the growth cells are destroyed and new skin can only grow from the outer edges of the burned area to the center. First and second degree burns heal much quicker because the growth cells are not destroyed.

First Aid. The first objective when administering first aid to burn victims is to treat for shock, then relieve pain and prevent infection. Death is frequently caused by shock before the burn itself has had time to poison the system.

First degree burns are usually treated by the application of cold water to the burned area or by submerging the burned area in cold water. A dry dressing is applied if necessary.

The burned part should be submerged in cold water (not ice water) until the pain subsides from second degree burns. If the burned area cannot be immersed in cold water, freshly laundered cloths should be wrung out in ice water and applied to the area. A dry protective bandage of clean cloth or sterile gauze should then be applied. DO NOT BREAK ANY BLISTERS OR REMOVE TISSUE.

If the legs or arms are affected, they should be kept elevated. Don't use home remedies, sprays, ointment, or antiseptic preparations on severe second degree burns.

Third degree burns, being the most serious and dangerous of the three, require more attention. You should not attempt to remove any of the particles of charred clothing adhered to the affected area. The burns should be covered with thick sterile dressings or any other clean cloth. If the legs are involved, they should be elevated and the victim should not be allowed to walk around. The arms should be kept above the victim's heart level if they or the hands are burned. Cold water should not be used for treatment of third degree burns because it may intensify shock reaction. Cold compresses may be applied to the hands, feet, or face if they are not burned.

Victims with face burns should be kept in a sitting position or propped up and under observation at all times for breathing difficulty.

Transportation to the hospital or other medical assistance should be made as soon as possible.

Exercises (631):

1. What is a first degree burn?

2. A burn that involves all layers of the skin is classified as what degree of burn?

3. Which burns are the most dangerous?

4. Why do third degree burns heal so slowly?

5. What is the first objective when administering first aid to burn victims?

6. What type of dressings should be applied to second degree burns?

7. Why should cold water NOT be used for the treatment of third degree burns?

632. Identify facts about chemical and electrical burns and their treatment.

Chemical Burns of the Skin. When irritating chemicals come into contact with the skin, injury to the tissues commences almost instantly, and first aid should be applied immediately. Acid burns are nonprogressive injuries. Alkali burns progress with time, and a burn that first appears to be minor may develop deep inflammation and tissue destruction. The best first aid is to flush the chemical away with various amounts of water. If first aid directions for specific types of chemicals are available on labels or other sources, they should be followed. After the chemical has been flushed from the affected area, supply additional first aid by putting a sterile dressing over the affected area and transporting the victim to a medical facility immediately.

Chemical Burns of the Eyes. Acids, alkalis, chemical powders and liquids can impair vision, cause serious chemical eye burns, or total blindness. The type of chemical will, in effect, determine the degree of injury. Regardless of the type of chemical, remember one thing: flush the eyes with large amounts of cool water immediately. Powdered particles may remain trapped under the eyelids. Gently separate the eyelids and continue to flush with water. Cover both eyes with a sterile compress. This is done to prevent further damage to the injured eye because of the sympathetic movement of the uninjured eye. Transport the victim to a medical facility immediately.

Electrical Burns. Electrical burns are often more serious than they first appear, since they often involve deep layers of the skin, muscles and even the internal organs. Initial care requires covering the injury site with a clean, sterile cloth and transporting the victim to a medical facility immediately.

Remember, in electrical burns, the shock is likely to affect the patient's heart and lung action. In most cases, the victim will require CPR if he is to live.

Exercises (632):

1. The severity of burns caused by ________________ progress with time.

2. What is the best first aid for chemical burns?

3. How would you treat chemical burns of the eyes?

4. Why are electrical burns often more serious than they first appear?

5. Most victims who have been burned by electricity will require what type emergency aid?

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CHAPTER 2

Transporting the Injured

YOU MUST BE constantly aware of the dangers involved when the victim must be moved or transported. Here, when we speak of "moving" a victim, we are referring to a situation where the victim is in immediate danger of his life, as in a burning building, a crashed aircraft, or a gaseous area. In this case, the victim must be removed to a safe area before a survey of his injuries can be made. When we speak of "transporting" the victim, we are referring to the removal of the victim from the place where he was given emergency first aid to the first-aider's vehicle. This requires extensive training and coordination on your part.

2-1. Rescue Carries

The method you may use for removing a victim from a danger area is governed by conditions of both the area and the victim. You must often make the decision under duress and with very little time to think. If you are experienced in all types of carries, you probably will make the right decision.

633. Specify the execution and limitations of the drag and backstrap carries.

Drag. The drag, as shown in figure 2-1, is used when the victim is near an exit, if the victim is extremely heavy, or where a lack of headroom makes other carries impractical. To execute the drag rescue, place the victim on his back. Then grasp him beneath the arms, and, moving backward, drag him to an area of safety. The drag may also be effected by placing the victim on a blanket or bunker coat and pulling him to safety.

When using the drag, always pull the victim in the direction of the long axis of the body, not side ways. Do not try to drag a victim up or down stairways.

Backstrap Carry. This carry is valuable if the extent of the victim's injuries does not prevent its use and if the weight of the victim is equal to or less than your own. If the victim is lying down and cannot help, you must also lie down, with your back against the victim's chest. In this position, you can reach over the victim and bring one of his arms over your own shoulder and hold it in place, as shown in figure 2-2,A. Then, by grasping the clothing of the victim at the hip with the other hand, you can roll him over on your back. From this position, you can then get on both knees, as in figure 2-2,B, then to one knee, and—finally—to a standing position, as shown in figure 2-2,C.

The backstrap carry is recommended for an unconscious victim; however, it is not recommended for victims with broken bones. NOTE: This carry cannot be made if you are equipped with a self-contained breathing apparatus.

Exercises (633):

1. State where and when the drag is used to move a victim.
2. How is the drag executed?
3. In what direction should you drag a victim?
4. When should you not drag a victim from a danger area?
5. What factors limit the use of the backstrap carry?
6. When can you not use the backstrap carry?

634. Specify the execution and limitation of the fireman's carry.

Fireman's Carry. The fireman's carry is recommended for you to remove a victim from a burning building. Victims of heat, smoke, and gases are generally found lying on the floor. If the victim is not

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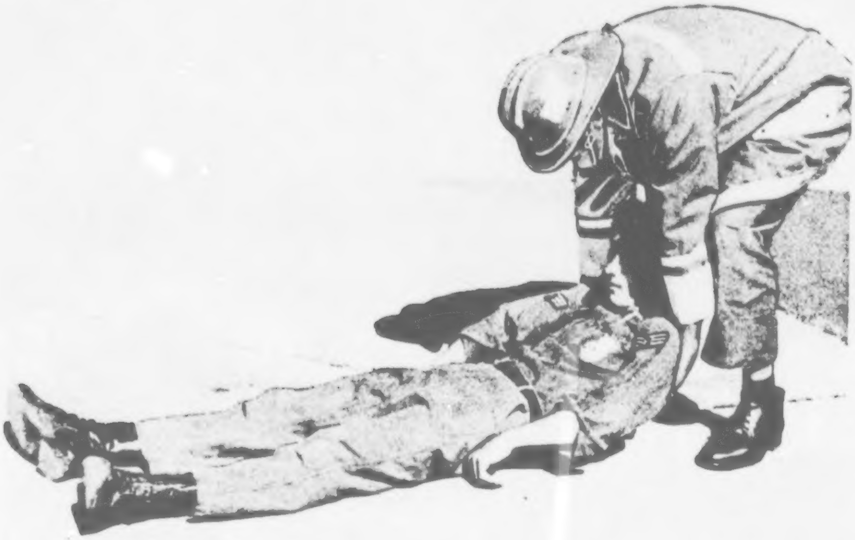
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Figure 2-1. The drag.

already in the face-down position, turn him over, supporting his head on his arm. (See fig. 2-3,A.) Straddle the victim, place your hands under his armpits, and lift to the standing position. Support him with your arm around his waist, and step in front of him. Grasp his right wrist and place your right shoulder against his midsection, then pull his right arm around the back of your neck as you assume a squat position (See fig. 2-3,D). The victim's body will then be draped across your shoulders. Slip your right arm between his knees, bring his right arm down to your right hand, and grasp his wrist firmly with your right hand. You are now ready to stand. Lift straight up, using your leg muscles to prevent injury to yourself. (See fig. 2-3,E.) This carry will enable you to carry a victim considerable distances without fatigue. Another distinct advantage of this carry is that you will have your left hand free for other uses. NOTE: This carry cannot be accomplished when you are equipped with self-contained breathing apparatus.

Exercises (634):

1. In what position should an unconscious victim be placed to execute the fireman's carry?

2. After the victim has been brought to the standing position, where should you place your right shoulder?

3. Why should you lift the victim straight up?

4. What are the advantages of the fireman's carry?

5. What are the disadvantages of the fireman's carry?

635. Specify the uses and limitations of common carries.

Arm's Carry. The arm's carry is recommended for carrying the victim for short distances. The victim is grasped under the back with one arm and under the knees with the other arm. He is carried high to decrease the fatigue rate of the carrier. The arm's carry is not recommended when the victim has a broken back or leg. (See fig. 2-4.)

Seat Carry. This is a two-party carry which merely consists of carrying the victim on a "seat" provided by the carrier's arms. (See fig. 2-5.)

Chair-Litter Carry. A convenient technique for carrying a person when a litter is not available is to seat the victim on a strong chair. This is also ideal for going up and down stairs, through narrow corridors, etc. (See fig. 2-6.)

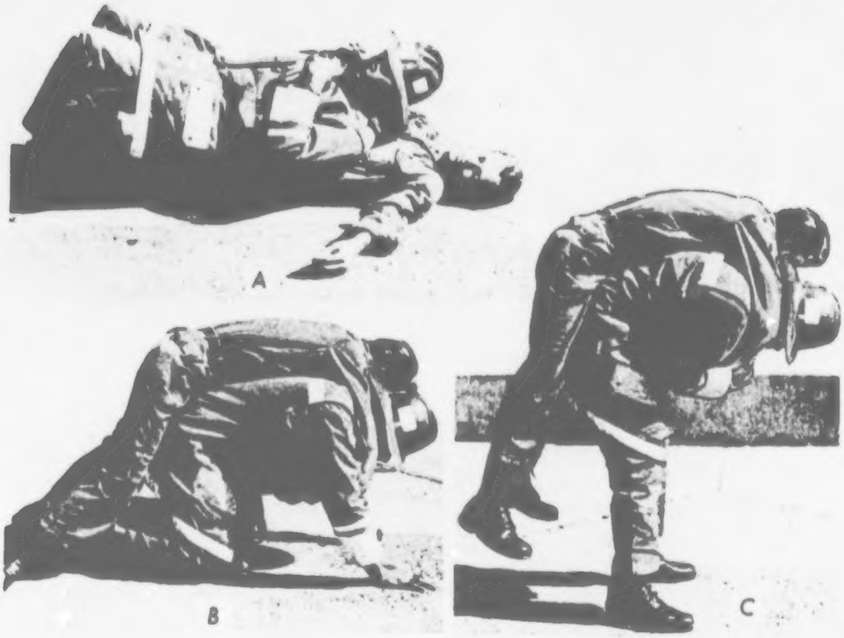

Figure 2-2. Backstrap carry.

Carry by Extremities. The chief use of this carry is for moving victims who have no serious injuries to the body. One person grasps the victim by the legs, and the other grasps the victim under the arms and around the chest. (See fig. 2-7.)

Three-Man Carry. In cases of severe injuries, the number of carriers should be increased to at least three. This procedure makes it possible to transport a victim with the least possible bending or twisting of his body. One of the group must be in command in order to coordinate the carry efforts. It is common practice to consider the individual at the victim's head to be leader of the crew. Three carriers line up on one side of the victim, and the leader gives the word "prepare to lift." Each person kneels on the knee nearest the victim's feet, so that one person is at the victim's shoulders, one at the hips, and one below the knees. All three are on the same side. Each carrier then places his hands and forearms under the victim. (See fig. 2-8,A.) The individual at the victim's head places his hands under the shoulders; the center carrier places his hands under the pelvis or hips and the small of the back; and the third carrier places his hands under the knees and ankles. At the command "lift," the carriers raise the victim and place him on their knees without releasing their hands. (See fig. 2-8,B.) At the command "raise," all carriers raise slowly to the standing position and hold the victim closely against their chests. (See fig. 2-8,C.) A victim may be lowered by reversing the operation, but always at the command of the leader.

Exercises (635):

1. How is the arm's carry made?
2. The arm's carry should not be used when the victim has what type of injuries?
3. How is the seat provided in the seat carry?
4. The chairlitter is ideal for use when?
5. Describe how a victim is carried by the extremities.
6. The carry by extremities should be used when a victim has what type of injuries?
7. When a victim has serious injuries, what is the minimum number of people needed to move him?

8. Why are three persons required to move a victim with serious injuries?

9. Which member of a carrying team is normally the team leader?

10. Where are the three persons positioned for lifting the victim?

2-2. Lifting Patients

If a victim must be transferred before a litter is provided, you may use a strong blanket or other suitable material to lift and move the victim. Blankets and such should never be used if it is suspected that the victim has back and/or neck injuries, unless the danger is so great that a backboard cannot be secured before the victim is moved.

The two techniques discussed below are among the most commonly used methods for lifting and carrying patients with spinal injuries. Both are quite effective since they provide rigid immobilization of the spine through the use of a long spine board. Since these procedures must be carried out carefully and in a certain sequence, they should not be used to remove a patient from a hostile environment where speed is required, but only if no danger is involved and the patient's condition has been stabilized.

636. Specify the execution of the traction blanket lift and of the three-man hammock carry.

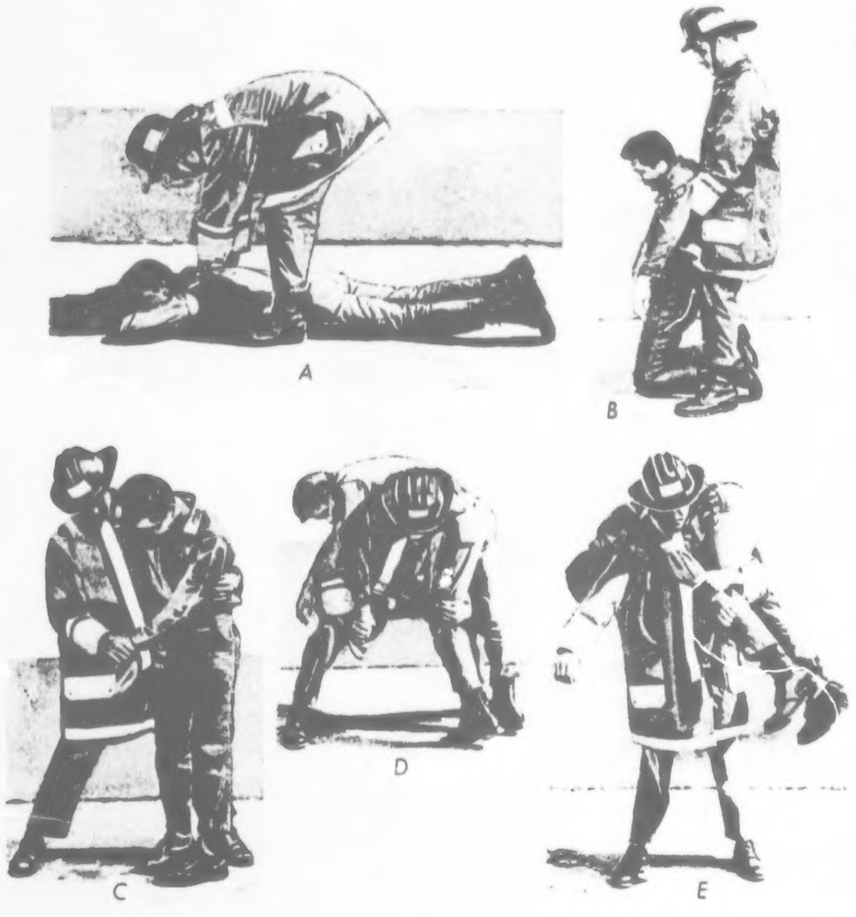

Figure 2-3. Fireman's carry.

Traction Blanket Lift. Five persons are required to effect the traction blanket lift. The following paragraphs will tell you how to make the lift. Pleat a standard Army blanket in folds 1 to 1½ feet long on the floor just above the victim's head so that the pleated blanket will feed out from the bottom. Fold back the top pleat so that the individual at the head and two persons at the victim's shoulders can kneel on the fold. The position of the carriers is as follows:

Member #1 (leader) takes a position on one or both knees and grasps the victim's head in the standard manner for applying traction. Members #2 and #3 kneel on one or both knees at the victim's shoulders, placing one hand flat under the shoulder blade and

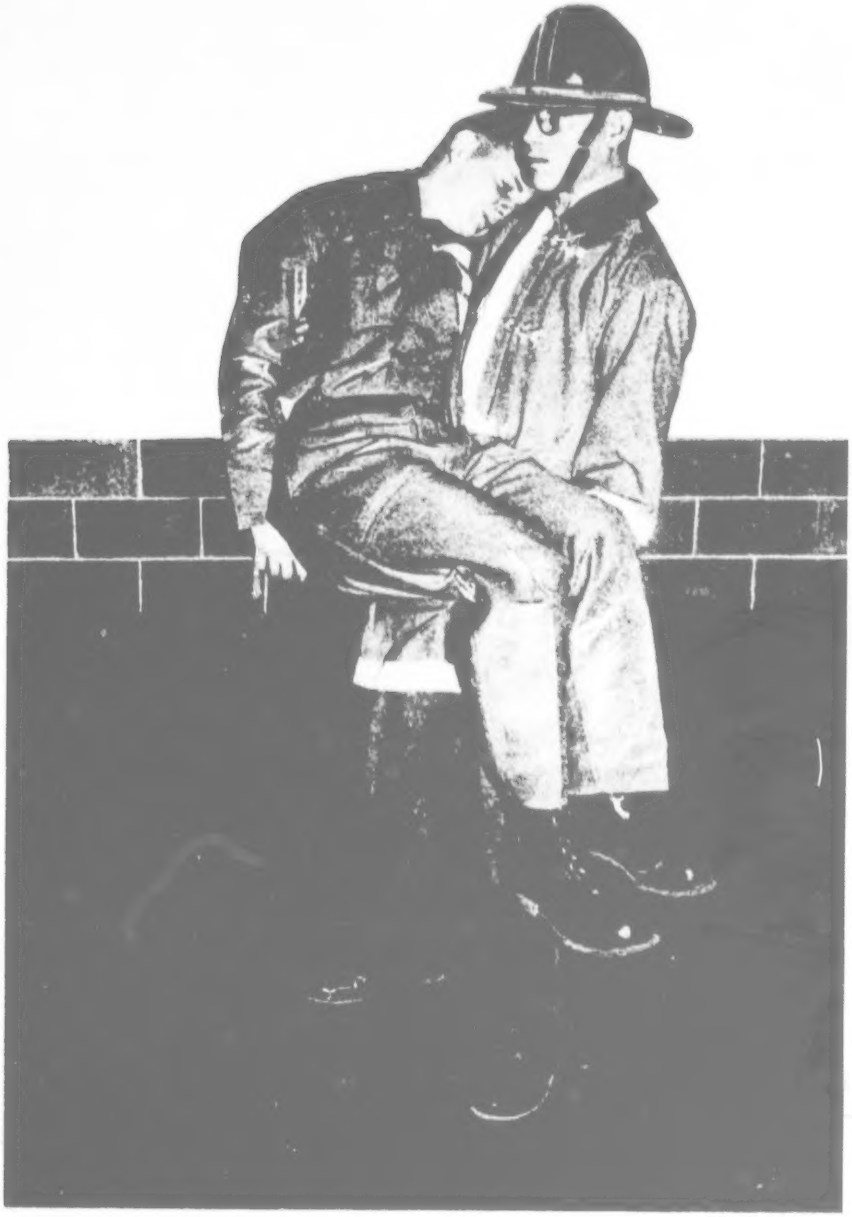

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Figure 2-4. Arm's carry.

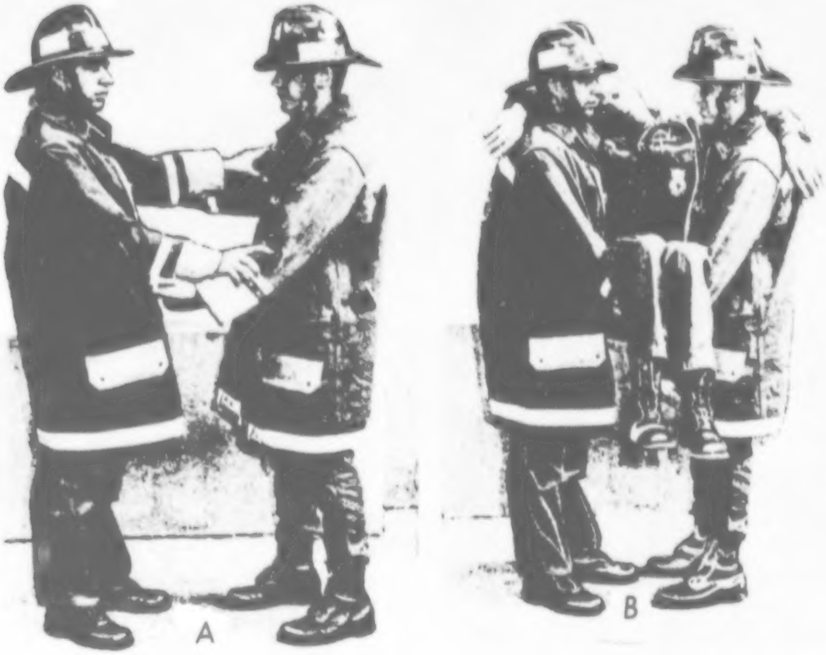

Figure 2-5. Seat carry.

the other in the armpit. Members #4 and #5 grasp the bottom pleat of the blanket and pull the blanket under the victim while #1, #2, and #3 hold the upper position of the victim's body in place.

When the blanket is in place under the victim, roll the blanket tightly at the sides until it fits the contour of the victim's body. Members #2 and #3 (on opposite sides) grasp the blanket with the top hands at the shoulder and the bottom hands at the lower back. Members #4 and #5 (also on opposite sides) grasp the blanket with top hands at the hips and lower hands below the knees. Member #1 remains at the head, holding slight traction.

At a signal, members #2, #3, #4 and #5 lean back in opposite directions, using their back muscles and body weight. This will lift the victim 6 to 8 inches from the ground so that a litter or backboard can be slid underneath the victim.

With this lift, as with all others, the members of the lifting team must remain alert for directions from the team leader. The team members must also keep alert to maintain their balance and prevent injury to themselves and/or the victim.

Three-Man Hammock Carry. The positions of team members to perform the three-man hammock carry are as follows.

Team member #1 (leader) is positioned on either side of the victim approximately at the shoulder. Member #2 is on the same side of the victim as the leader but at the hip. Member #3 is on the opposite side of the victim approximately at the waist (between #1 and #2). Each member kneels on the knee nearest the victim's feet.

The leader cradles the victim's head and shoulders with his top arm. He places his other arm under the victim's lower back. Member #2 slides his top arm under the victim's back ABOVE member #1's bottom arm and places his other arm just below the victim's buttocks. Member #3 slides his top arm under the victim's thighs above member #2's bottom arm. Number 3's other arm is placed under the victim's legs below the knees. NOTE: The hands of team members should be placed about halfway under the body at this point.

On signal from the team leader, the victim is lifted to the team member's knees and rested there while the hands are slid far enough under the victim to allow rotation of the hands inward to secure an interlocking grip. At the next signal, all team members stand erect with the victim.

Exercises (636):

1. How many persons are needed to effect the traction blanket lift?

2. How is the team leader positioned in relation to the victim when in position to make the traction blanket lift?

3. Where do team members 2 and 3 place their hands to position the blanket during the traction blanket lift?

4. Who pulls the blanket under the victim during the traction blanket lift?

5. What is done with the blanket after it has been pulled under the victim?

6. How high will the victim be lifted with the initial exertion?

7. Describe how the team members are positioned to effect the three-man hammock carry.

8. Which knee do all team members kneel on to make the initial lift?

9. Where does team member #3 position his arms during the three-man hammock carry?

10. How high is the victim lifted before the carriers interlock their hands?

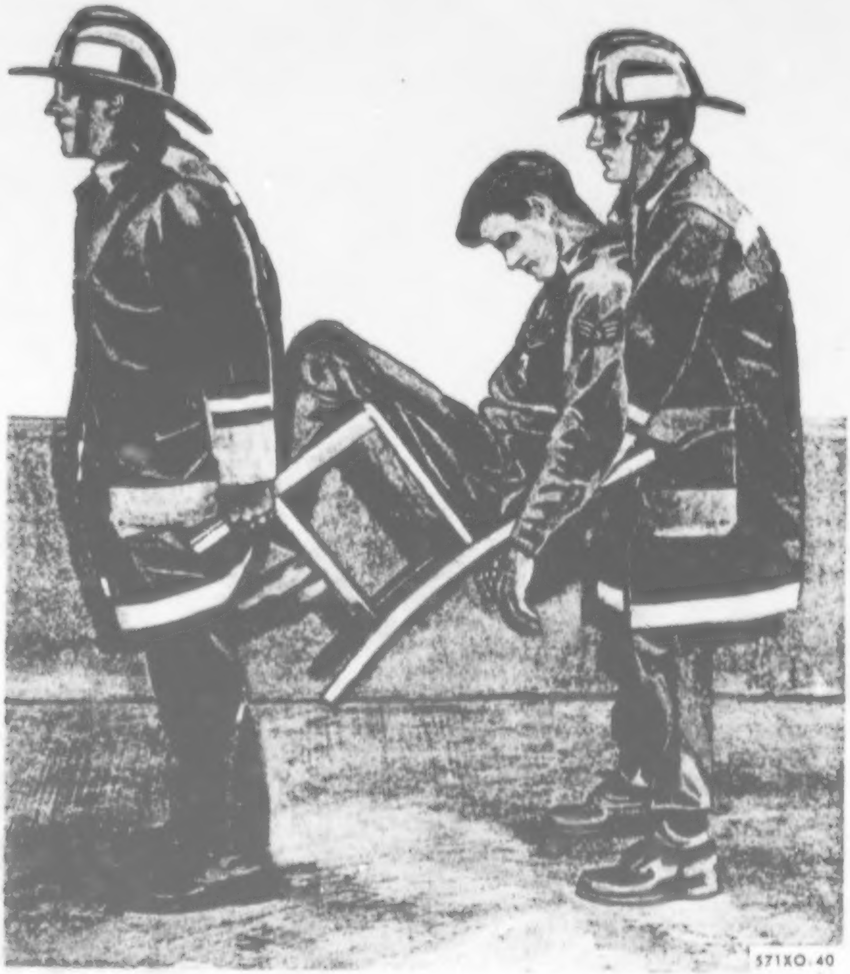

Figure 2-6. Chair-litter carry.

637. Specify how to make a four-man log roll.

Four-Man Log Roll. The log roll is most effective when a minimum of four team members are used to roll the victim. A fifth member or a spectator should be used to move the spine board. Three of the team members roll the victim as a unit, while the fourth team member maintains constant traction on the head and neck.

Remember, an evaluation of the victim's condition should indicate whether spinal damage has occurred. If so, rigid immobilization on the long spine board is REQUIRED. Additional support for neck fractures or dislocations can be provided by application of the cervical collar or a collar improvised from a rolled towel, multitrauma dressing, or folded blanket.

Assume that the victim is found on his back. One team member (the leader) positions himself at the head of the victim and applies gentle traction to the head and neck. The leader remains in this position and continues to apply traction until the victim is firmly secured to the board and ready for transportation. Again, a cervical collar or similar device will aid in maintaining traction.

When traction has been applied, another team member raises the victim's arm (on the side to which he is to be rolled) over the victim's head to prevent the arm from obstructing the rolling movement. Then the other three team members take up positions in a straight line along the victim's side, all kneeling on the same knee.

The team member at the victim's shoulder places one hand on the patient's farthest shoulder and passes his other hand over the victim's arm so that he can grasp the victim's body just above the belt line. The center member grasps the victim's body just below the buttocks. The bottom member places one hand

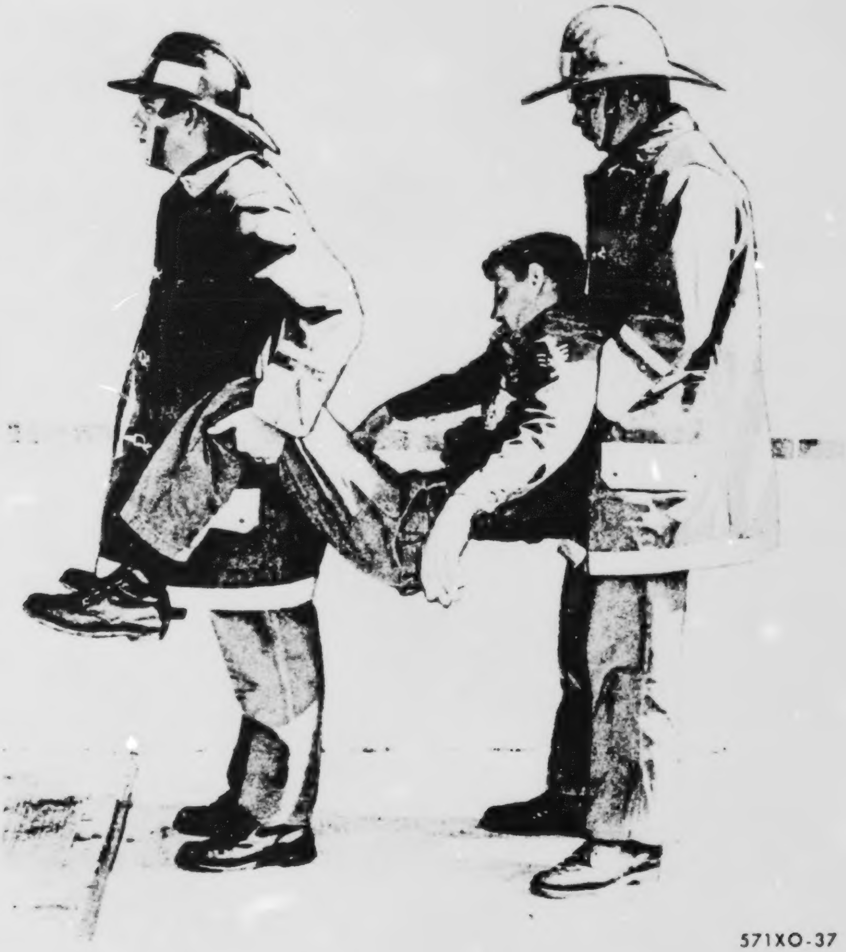

Figure 2-7. Carry by extremities.

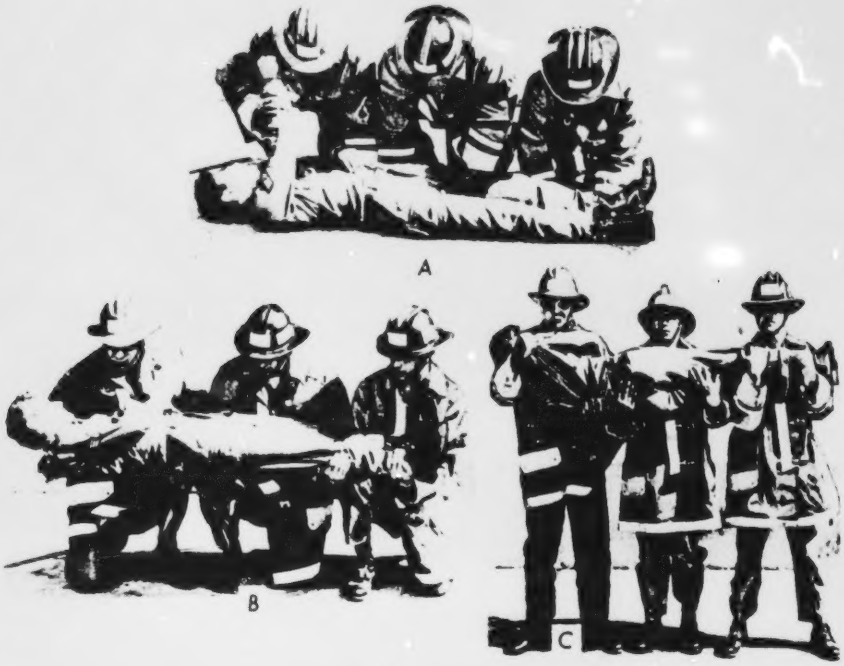

Figure 2-8. Three-man carry.

behind the victim's knees and the other hand on the victim's leg just below the calf.

When the leader is satisfied that proper traction is being applied and that all of the other team members are ready, he gives the signal for the other team members to roll the patient toward them. It is important for each member to coordinate his movements with those of the others so that the victim's body will be moved as a unit.

While the victim is held carefully in the rolled position, another team member (or spectator) slides the long spine board next to the victim, positioning it so that the victim's head and feet will be on the board when he is rolled onto it. The fifth person then places pads at points where voids will be created when the victim is on the board: under the neck, behind the small of the back, under the knees, and behind the ankles. The pads, which support areas of the body that do not contact the board, may be made from rolled towels, bandaging materials, or multitrauma dressings.

On the signal from the leader, the team members carefully roll the victim onto the board, assuring that the victim is moved as a unit. The fifth person can adjust the pads as the victim is lowered. When the victim is again on his back, the top member returns the victim's outstretched arm to the side.

Remember, the leader must be especially careful to coordinate his movements with the actions of the others, maintaining traction until the victim is rigidly immobilized on the board.

The victim should be secured to the board with snugly applied straps or cravats at the chest, thighs, and knees. Movement of the head should be prevented by securing it with a wide cravat applied over the forehead and passed through the slots in the side of the board.

NOTE: In some accident situations, the patient is found in the face-down position, and because of his injuries, it may be best to transport him in that attitude. The four-man log roll may be used for the patient in the prone position following the same procedures outlined for the supine position, with the exception of padding the voids.

Exercises (637):

1. What is the fifth team member, or a spectator, used for when the four-man log roll is made?

2. What is the leader doing while the other three team members roll the victim?

3. Why is one of the victim's arms rised over his head when he is rolled?

4. When is the order given to roll the victim?

5. Where are pads placed on the spine board? For what reason are they placed where they are?

6. When does the team leader relieve the traction that is maintained on the victim?

7. How is the victim secured to the spine board?

8. When a victim is to be transported in the prone position, what procedure is not followed?

638. Specify how a straddle slide is made and its use.

Straddle Slide. The four-man log roll requires sufficient room for the team members to walk around the patient and position themselves at the patient's side. In some accident situations, such as in a building collapse or a case where the victim is found in a narrow hallway or between immovable objects, it may be impossible to use the log roll technique. As an alternative, a patient with suspected spinal injuries can be moved to a full spine board by the straddle slide method.

As in all cases where injury to the spine is suspected, the team leader moves directly to the patient's head and applies gentle traction. In this case, however, the leader does not kneel, but rather bends at the waist and spreads his feet wide enough to allow the long spine board to pass between them. The leader faces the victim's feet. A second team member straddles the patient (facing the leader) and places his hands under the victim's arms just below the victim's shoulders. A third team member also straddles the patient, placing his hands at the waist. A fourth member positions the board lengthwise at the victim's head. This member's job is to slide the board under the victim when the other members lift the body slightly.

At a signal from the leader, the other team members lift the victim just enough to allow the board to pass under the body. The board should be slid in one smooth and unbroken movement. If the victim's upper body is lifted high enough for the board to pass under, the buttocks and legs offer little resistance to the smooth board. When the spine board is completely under the victim, the team members can lower the victim carefully and then strap him firmly in place. Voids should be padded as in the log roll technique.

Exercises (638):

1. When should the straddle slide be used?

2. In what cases is traction applied to the victim's head and neck?

3. What is the position of the team leader when the straddle slide is used?

4. Where is the third team member positioned when making the straddle slide?

5. When the straddle slide is used, how high is the victim lifted?

6. For the straddle slide, how should the board be slid under the victim's body?

2-3. Other Methods of Transport

There may be times when you will have to remove an injured or unconscious person from a building without the use of stairways and/or elevators. There will also be times when you will have to use makeshift items to transport a victim. The following information is only a sample to show you what a little ingenuity can produce. You should also try to think of additional means of transporting victims.

639. Identify facts about makeshift methods of transporting victims.

If you have to have a stretcher to move a victim and one is not on hand, there are several things you may use to make do.

A straight ladder can be used, if care is taken to prevent the victim from falling off the narrow surface. One way of securing the victim is by using two web belts linked together. Another way is by securing the victim with rope.

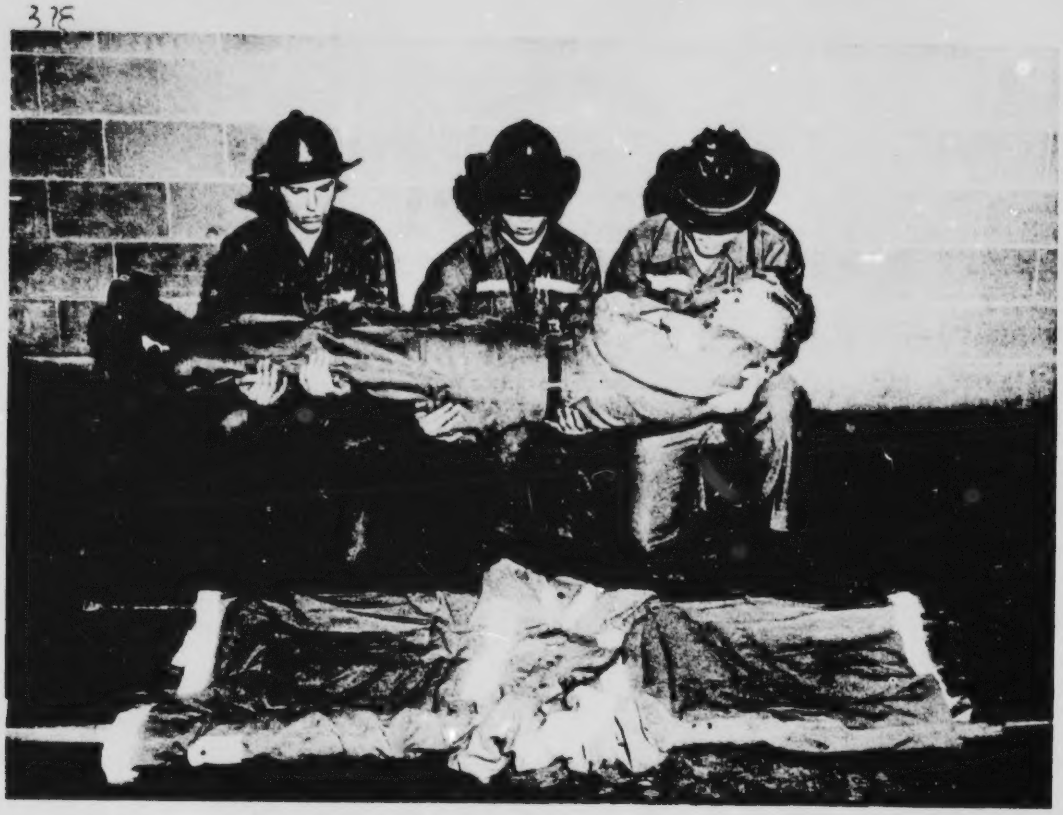

Figure 2-9. Make-shift stretcher.

Making Stretchers. Stretchers can be made by using two bunker coats and two pike poles. (See fig. 2-9.) They may also be made by using rugs, blankets, or other clothing. If available, an ironing board, door, table leaf, or other such object may also be used.

To make a stretcher using a blanket and poles, you should proceed in the following manner. Spread the blanket out flat. Fold the blanket from left to right (width-wise) to about 8 inches past one-third the blanket width. Insert one pole through the loop formed when the blanket is folded, and lay the second pole on top of the double-thick section of the blanket about 6 inches from the open end of the double-thickness. Bring the remaining single thickness of blanket back over the first pole. This will give you a stretcher with three thicknesses of blanket for the bed. The victim's weight will hold the blanket in place over the poles. Before the stretcher is carried, insure that the poles are as nearly even with each other as you can get them and test lift the stretcher as you would any stretcher to be sure that the stretcher will withstand the victim's weight.

NOTE: Any makeshift device used that has buttons, hooks, snaps, etc., should have these devices arranged so as not to cause discomfort to the victim if at all possible to do so.

Stretcher Carry. The procedure for placing a victim on a stretcher is the same as preparing to lift on the three-man carry (See fig. 2-9.) Although a stretcher squad should consist of four persons, two or three persons may carry a stretcher under certain circumstances. If three people are to carry a stretcher, their positions are: one at each end of the stretcher, and one at the middle, with all members facing the same direction. (See fig. 2-10.) The stretcher must be picked up in this position since there is no help available for the individuals to turn around after the stretcher is raised. The stretcher bearers should walk out of step to reduce bouncing of the victim. The stretcher should be carried as shown in figure 2-10 so that the bearer at the victim's feet may watch the victim for signs of change in his condition and/or discomfort while he is being transported.

Using a Ladder. Many times, planned escape routes are cut off by fire, and windows offer the only path to safety. For this reason, you'll find yourself placing ladders at window openings of areas where victims are trapped. To assist a victim down a ladder, you merely precede him down the ladder. The victim descends the ladder with one of your arms on either side of him. It is a good idea to talk to the victim while descending the ladder to reassure him that he is being taken to safety and to dispel any fears he may have of ladders.

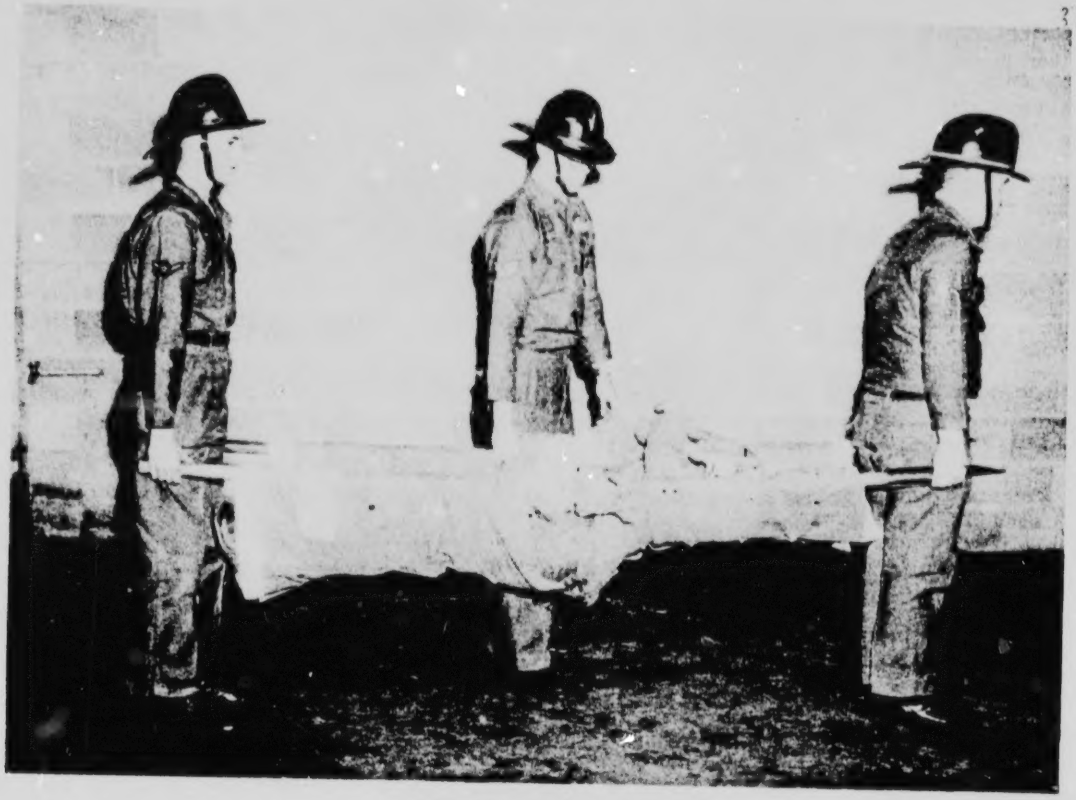

Figure 2-10. Carrying a stretcher.

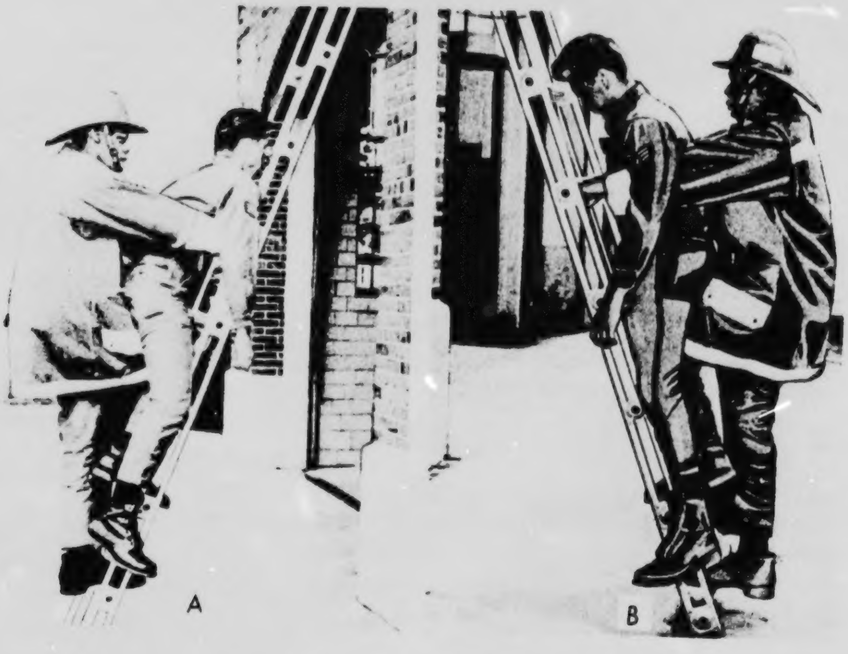

Figure 2-11. Bringing victim down a ladder.

If the victim is unable to proceed on his own, you an place him astride one of your knees with one of his legs on either side of your leg, and cautiously proceed down the ladder. (See fig. 2-11.)

Exercises (639):

1. How do you make a stretcher using bunker coats and pike poles? (Refer to fig. 2-9).
2. When a stretcher is made using a blanket and poles, how is the blanket kept from slipping off the poles?
3. Why should you test lift a makeshift stretcher?
4. How many people should be used to carry a stretcher when enough people are available?
5. In what direction should the stretcher bearers face? Why?
6. How do you assist a victim who can proceed on his own down a ladder?
7. Why should you talk to a victim while assisting him down a ladder?

Rescue

THE AIR FORCE has a need for special rescue companies in the fire department, as large metropolitan areas do. Air Force bases are much smaller than these cities and can, therefore, combine several firefighting duties. However, for better organization, specific individuals and crews are assigned the primary job of rescue. Normally, each fire protection specialist in the Air Force is a rescuer as well as a firefighter. But you, the firefighter, cannot wait until the need arises before you learn how to rescue personnel from various hazardous locations. You must know in advance what is to be done, what tools you will use, and how you will use them. Lives are certainly more important than property; therefore, rescue efforts come before anything else.

The senior officer decides if rescue operations will be required. Extreme care should be taken in moving victims from the area in which they are found. Inexperienced handling may greatly aggravate injuries. Compound fractures may be transformed into more serious, or even fatal, injuries, unless removal is made in the proper manner. When a fire is not serious or after it is under control, and if required medical aid is at hand, you may find that immediate removal of injured personnel is not desirable. In any case, medical assistance should be available at the earliest possible time. The removal and handling of deceased personnel should be done by medical personnel. This is true except where haste is necessary to save the bodies or if entry is too hazardous for medical personnel.

3-1. Principles of Rescue

640. State the principles of rescue operations.

Rescuers and the rescue services have a long history of outstanding and beneficial service to mankind. Evidence can be found where people involved in accidents in ancient civilizations had their lives saved and their injuries treated with skill and care. Rescue, then and now, remains essentially the same in regard to performing with skill and care. The Air Force has recognized that it is very necessary to have rescue crews highly trained in rescue procedures.

Rescuers must be able to make a quick, comprehensive survey of the injured at the scene of an accident. They must have enough experience to make prompt and correct decisions of what must be done to provide the best possible care for victims. The duties of a rescue team may vary from place to place, but the main reason for having a rescue team is to have SKILLED rescue personnel ready to perform when needed.

Rescue is not an area in the fire protection career field that can be taken lightly. Great care should be shown in the selection of personnel to perform as rescue team members. We know highly trained personnel are needed to minimize life loss and properly care for injured victims in a variety of incidents that can occur in today's Air Force. Automobile and aircraft accidents, fires, drownings, explosions, and natural disasters occur daily. These incidents often add up to major loss of life and much human suffering. You must be prepared educationally, mentally, and physically to deal with these problems. After your initial training in rescue procedures, and from experience gained by exposure to emergencies, your future performance will depend upon your ability to learn new techniques and retain past knowledge for use in other emergency situations. You must have enthusiasm for the job in order to continue learning new methods, techniques, and procedures. Each individual incident requires skilled rescue team members to show physical endurance, self control, and competent skills while performing rescue.

Exercises (640):

1. What is the main reason for having a rescue team?

2. How must you be prepared to deal with the problems of being a rescue crew member?

3. What will your future performance as a rescue team member depend upon?

4. Each individual incident will require you to display what traits as a rescue crew member?

3-2. Breathing Apparatus.

In order to maintain a maximum degree of efficiency in both aircraft and structural fire incidents, rescue personnel must know how to protect themselves. To enter a smoke-filled atmosphere and be overcome is sheer folly. It may be necessary for you to enter a smoke-laden atmosphere many times, but it is not necessary to enter it unprotected. There is one type of breathing apparatus that will allow you to enter various contaminated atmospheres. It is independent of the oxygen in the contaminated atmosphere. The more you know about it, the more proficient you will become in its use. This unit is the compressed-air breathing apparatus.

641. Specify procedures for the inspection of self-contained breathing apparatus.

Compressed-Air Breathing Apparatus. The compressed-air breathing apparatus used by rescue personnel is designated by technical orders as a self-contained breathing apparatus. It can be one of several manufactured brands. The apparatus selected is a representative model. There are other versions equipped with an audible low-cylinder-pressure alarm. Others are equipped with the alarm and a pressure-demand regulator and mask to provide a positive mask pressure in place of the demand regulator and mask.

This type of self-contained breathing apparatus provides safe breathing air to the user in toxic atmospheres, regardless of the concentration of toxin. It also supplies safe breathing air in an oxygen-deficient atmosphere. The apparatus (see fig. 3-1) consists of mask exhalation valve, chest strap, breathing tube, quick connect coupling, waist belt, side strap, locking tab, regulator shutoff valve, control lever, emergency bypass valve, regulator, regulator pressure gauge, regulator hose coupling, cylinder valve, cylinder pressure gauge, cylinder clamping lever, chest buckle plate, and the air cylinder itself. These components are common to all AF breathing apparatus and will vary in size and shape between makes and models.

Members of the rescue team must at all times have their equipment ready to go. Make certain that the unit is properly prepared for instant use. You can do this by following the technical order specifications for use, storage, and inspection. The breathing apparatus is inspected daily and after each use with a complete operational test made every 90 days.

Inspection. To prepare this unit for inspection, place the carrying case on a flat surface with the cover up. (See fig. 3-2.) Check the cylinder to be sure that it is pressurized to a pressure of between 1800 and 1980 psi (at 70° F.). If the cylinder pressure is lower than

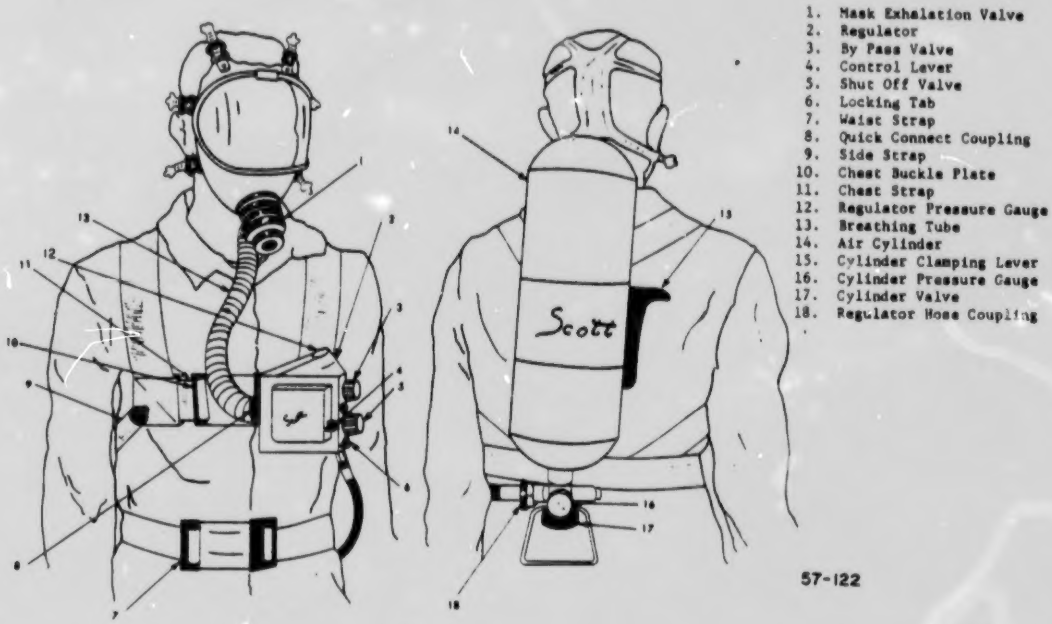
1. Mask Exhalation Valve
2. Regulator
3. By Pass Valve
4. Control Lever
5. Shut Off Valve
6. Locking Tab
7. Waist Strap
8. Quick Connect Coupling
9. Side Strap
10. Chest Buckle Plate
11. Chest Strap
12. Regulator Pressure Gauge
13. Breathing Tube
14. Air Cylinder
15. Cylinder Clamping Lever
16. Cylinder Pressure Gauge
17. Cylinder Valve
18. Regulator Hose Coupling
Scott
57-122

Figure 3-1. Self-contained breathing apparatus components.

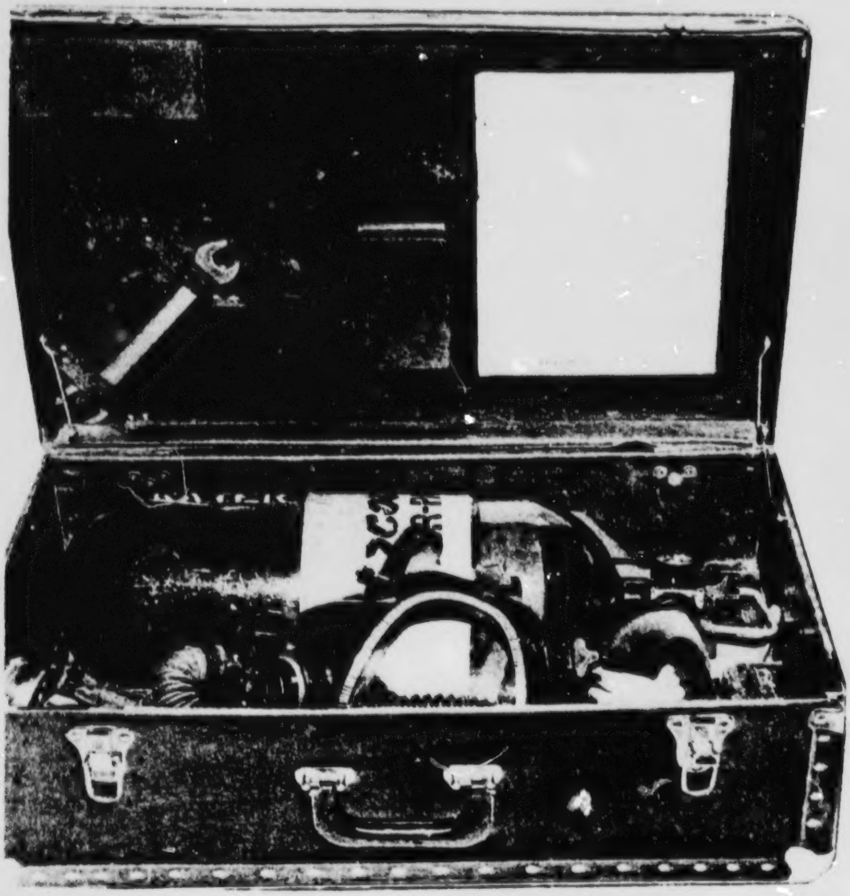

Figure 3-2. A stored air pack.

1800 psi, it must be recharged. The pressure should never be higher than 1980 psi if the person charging the cylinder follows the charging instructions. When the cylinder meets this requirement, be sure that the cylinder valve (see fig. 3-3) is closed. If the valve is open, turn the handle clockwise to close it. Then release the pressure in the cylinder-to-regulator hose by opening the regulator bypass valve. (See fig. 3-1, item 3.) Close the bypass valve finger-tight after all the air has been bled off. Then check the regulator shutoff valve (fig. 3-1, item 5) to see that it is fully open and in the LOCKED position.

The regulator (fig. 3-1, item 2) of the compressed-air breathing apparatus is used to reduce the pressure of the air coming from the cylinder to a usable pressure at the facepiece. The demand-type regulator will not allow air to flow through the regulator until a slight vacuum is caused by the wearer's inhaling with the facepiece securely in place over his face. The regulator shutoff valve of the apparatus is usually in the LOCKED OPEN position for immediate use. The gage on the regulator (fig. 3-1, item 12) indicates how much longer you can use the apparatus safely. The bypass valve on the regulator is used to direct the air from the cylinder around the demand section of the regulator. This gives a steady, positive airflow in case of a faulty regulator. This procedure is also used to "blow out" the facepiece if the facepiece is put on in a contaminated atmosphere or to give clean air under positive pressure to a victim overcome in a contaminated atmosphere. The air pressure is regulated by the bypass valve. Take care to prevent too high a pressure within the facepiece; this would cause the air supply to be exhausted in a very short period. Only enough air should flow into the facepiece to allow comfortable breathing. If you ever need to use the bypass valve because of a faulty regulator, turn it on and seek fresh air immediately.

Hoses. Check all hoses for condition, paying special attention to the connectors and threads.

Face mask. Inspect the face mask for any signs of damage and/or dry rot. The lens should be clean and free of scratches or any impairment to normal vision. Check the adjusting straps and catches for condition.

Inspect the exhalation valve (fig. 3-1, item 1) for damage/obstructions, and test by operation as shown in figure 3-4.

Cylinder. Inspect the cylinder and related parts for damage and security. (See fig. 3-1, items 14, 15, 16, 17, and 18.)

Harness. Check the harness and backplate for condition, paying special attention to buckles/fastening devices. (See fig. 3-1, items 7, 9, 10, and 11.)

Case. Inspect the air pack case for any damage and/or missing parts. Pay special attention to the shock pads and holders. Insure that the wrench and operating instructions are present, are in their proper place, and are in good shape. Also check for any forms and/or inspection check sheets that may be locally required.

Before returning the unit to the carrying case, unbuckle the waist belt, shoulder straps, and right side strap. Then place the cylinder in the slot in the case with the backplate down. Fully extend the side straps, but do not unbuckle the left side strap. Position the regulator against the rubber pad at the forward edge. Loop the shoulder straps and side straps over the top of the cylinder, with the waist belt in a neat orderly loop under the cylinder valve.

The head straps on the mask should be fully extended, and the center of the head harness should be folded inside the mask to protect the lens. The mask connector should go on top of the head harness, and then the mask should be placed inside its plastic bag. The mask is then placed at the right side of the cylinder valve inside the case. Secure the cover of the carrying case, first being sure that all straps are clear of the edges.

REMEMBER: Always be sure you have the correct TO and/or manufacturer's data for the specific apparatus you are inspecting. Many of the various makes and models look alike but are in fact very different. Whatever you do, don't try to mix parts without first checking the TO. You may not know that the swap won't work until it is too late—in a smoke-filled area.

Exercises (641):

1. When should a breathing apparatus be inspected?

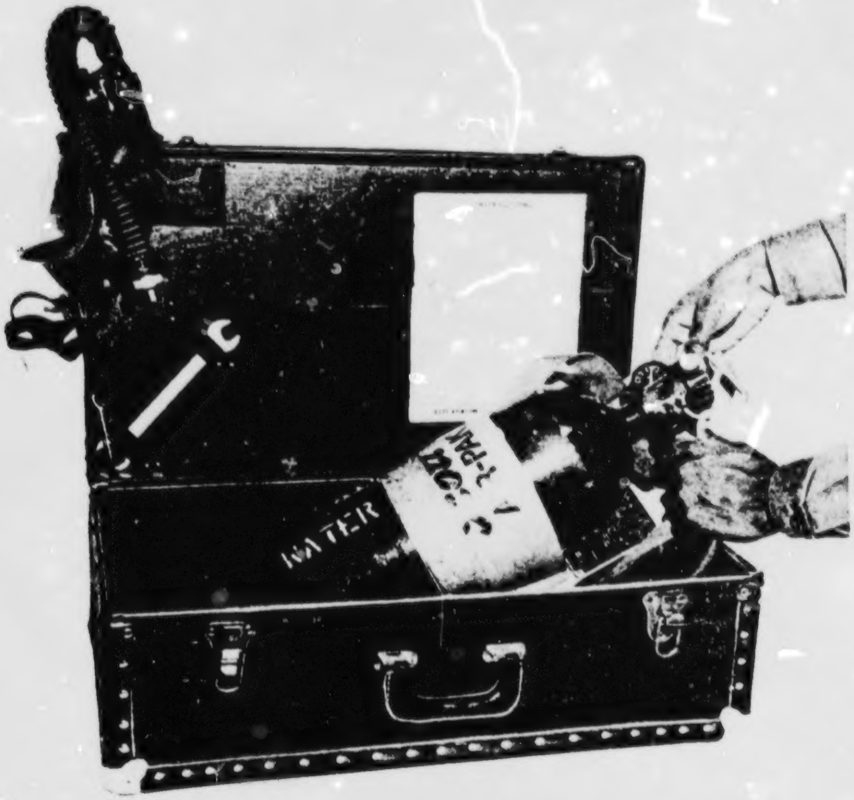

Figure 3-3. Checking the cylinder valve.

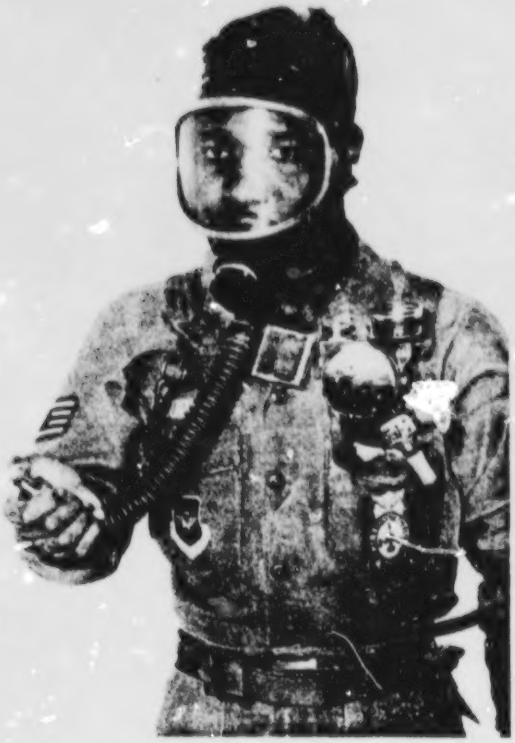

Figure 3-4. Checking the exhalation valve and face mask.

2. How is the pressure in the cylinder-to-regulator line relieved?

3. How tight should you close the bypass valve?

4. What do you do when you check the exhalation valve on the air mask?

5. What parts of the harness require special attention during an inspection?

6. When inspecting an air pack case, what items should you insure are present?

7. Which harness strap should be left hooked up when the air pack is returned to its case?

642. Specify procedures for operation of the Scott and MSA breathing apparatus.

Operating Procedures—Scott. The procedures for operating the Scott air pack (see fig. 3-2) are as follows:

1. Remove mask from carrying case and check air cylinder pressure gauge for "full" (1980 psi) indication, as shown in figure 3-3.
2. Check regulator shutoff valve (yellow knob) on the regulator for fully OPEN position.
3. Check emergency bypass valve (red knob); turn it clockwise to CLOSED position.
4. Open the cylinder valve fully, and lock. Check the regulator pressure gauge; it should read the same as the air cylinder pressure gauge. (When there is a difference in the two pressures, use the lower reading for working time.)
5. Open the emergency bypass valve slightly to check air flow, then close.

To don the air pack, put the harness on as if it were a coat. Lean forward slightly, fasten the chest strap, adjust the side straps, straighten up, and fasten waist buckle. (See fig. 3-5.) NOTE: The warning bell will sound at 400 psi; at 300 psi you have 4 minutes of air remaining. This should allow sufficient time to leave the danger area.

Operating Procedures—MSA. The procedures for operating the MSA air pack are as follows:

1. Remove mask from carrying case; check air cylinder pressure gauge for "full" (2000 psi) indication.
2. Check regulator shutoff valve (yellow knob) on the regulator for fully CLOSED position.
3. Check emergency bypass valve (red knob); turn it clockwise to CLOSED position.
4. Open the cylinder valve fully, and lock. Place thumb over mask connection coupling on regulator, open regulator valve, and check regulator pressure gauge; it should read the same as the air cylinder pressure gauge. (When there is a difference in the two pressures, use the lower reading for working time.)
5. Air should flow freely from mask connection on regulator when thumb is removed. With thumb blocking air flow from regulator, open regulator bypass valve (red knob); air should force past thumb at full force of air tank.

The MSA air pack was designed to don over the head. Open the case, and stand at the end of the case with the cylinder valve away from you. Check harness straps to ensure that they are off to the side of the back pack. Grasp the pack at approximately the center of the air bottle, and hold the entire pack over the head. At this point, the side straps should slip over the elbows. Lean over and rest the pack on the upper back and shoulders, then let the pack slide to a comfortable position. As your hands slip over the side straps in front, grasp the ends of the straps (one on each side) and pull to tighten. After tightening the

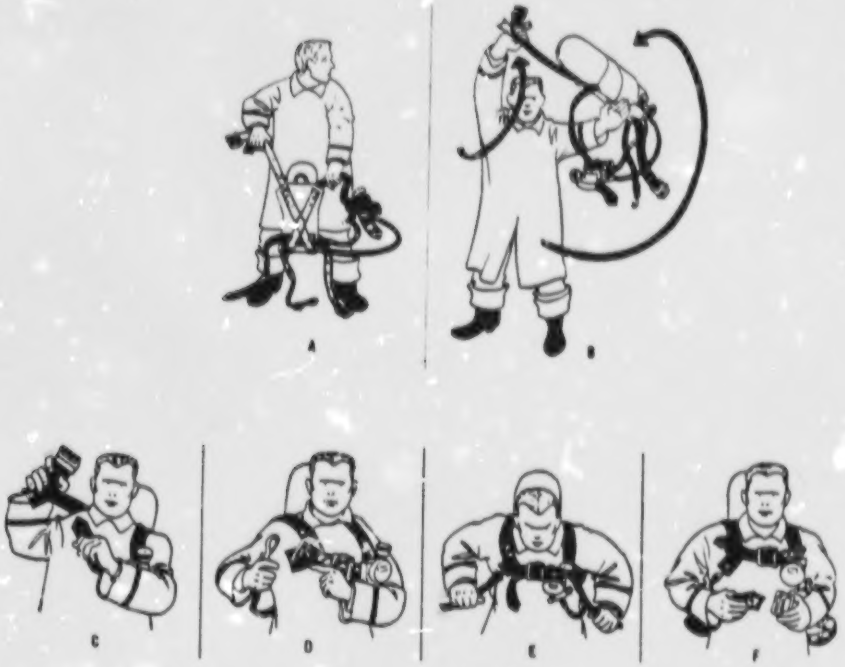

Figure 3-5. Donning the Scott air pack.

side straps, fasten and adjust the waist strap. Fastening of the chest strap is optional, but is encouraged. NOTE: The alarm sounds at 540 psi. This should allow sufficient time to leave the danger area.

Exercises (642):

1. When operating a Scott air pack, in what position should the red and yellow knobs be before the cylinder valve is turned open?

2. When there is a difference between the pressure readings of the regulator pressure gauge and the air cylinder pressure gauge, which reading should you use for working time?

3. At what pressure will the warning bell sound on the Scott air pack?

4. When the MSA air pack indicates full, there should be __________ psi pressure in the air cylinder.

5. How do you compare the regulator pressure gauge reading with the air cylinder pressure gauge reading on the MSA air pack?

6. Explain how to check the operation of the regular bypass valve on the MSA air pack.

7. At what pressure does the alarm sound on the MSA air pack?

643. Specify how to don the face mask for the breathing apparatus and its operation.

Put on the face mask, placing your chin in first and pull the straps over head. (See fig. 3-6.) Tighten straps, starting at neck straps and proceeding upward until all straps are tight. (See fig. 3-7.) Be sure to tighten the same level straps on each side at the same time. Failure to do so may result in failure of the mask to set correctly on the face, and leaks may develop.

Check the mask for leaks by holding the thumb over the breathing tube and inhaling slowly. (See fig. 3-4.) The mask should collapse the breathing tube. Exhale to check the exhalation valve; the air should escape freely. If leaks are detected, the straps should be readjusted. Should leaks continue, replace the mask.

Connect the breathing tube to the regulator handtight when you are ready to enter the contaminated area. (See fig. 3-8.) Check regulator pressure gauge; it should read FULL. This will operate the mask for approximately 30 minutes. Check the quantity of air remaining. When the regulator gauge indicates 400 psi (Scott) or 540 psi (MSA) on the main line, you have approximately 4 minutes air supply remaining. Leave the contaminated area immediately. After leaving the contaminated area, disconnect the breathing tube and remove the mask.

NOTE: The emergency bypass valve (red knob) will be open only when you fail to get an adequate air supply. If the demand type regulator should fail to operate, the bypass valve must be put into operation slowly by opening (turning counterclockwise) until you are receiving an adequate amount of air. Leave the contaminated area immediately. BE CAREFUL NOT TO CRIMP BREATHING TUBE WHILE THE EMERGENCY BYPASS VALVE IS IN USE. The emergency bypass valve provides a continuous flow of air bypassing the regulator mechanism. Close the regulator shutoff valve (clockwise) after the bypass valve is open. Do not use unnecessary force.

Exercises (643):

1. When you tighten the straps on a face mask, which ones should you start with?

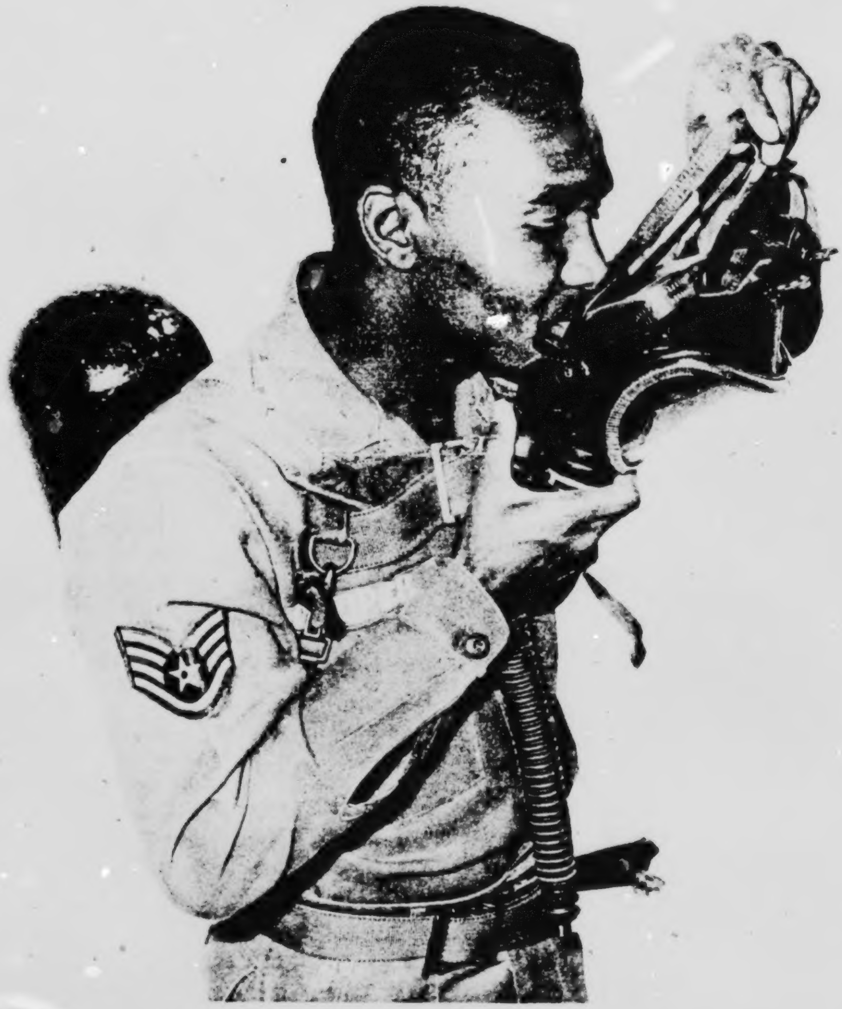

Figure 3-6. Putting on the face mask.

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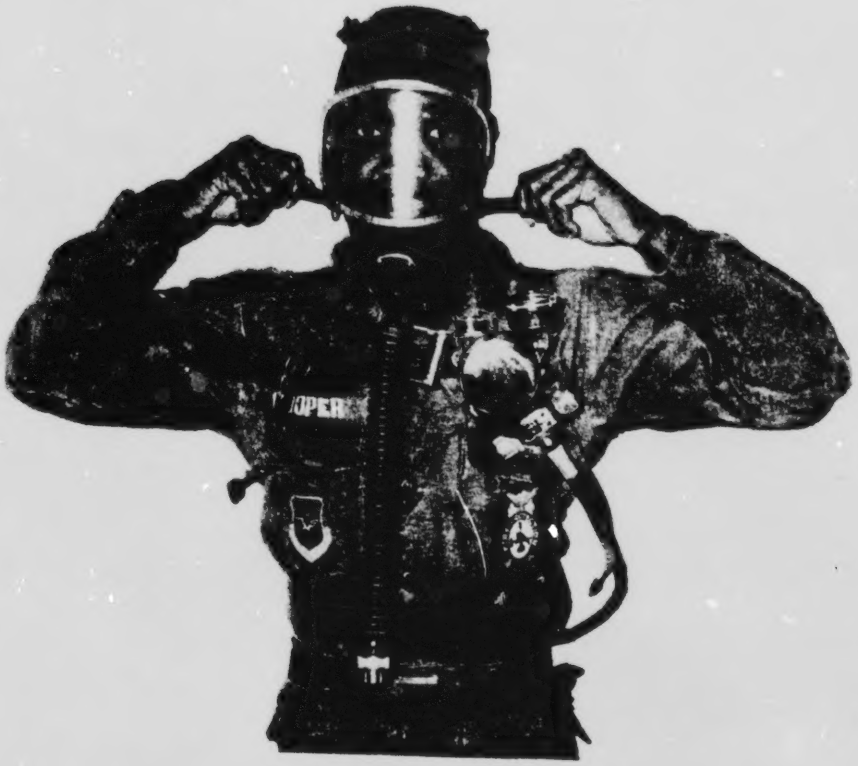

Figure 3-7. Adjusting the face mask straps.

2. How is the mask checked for leaks?

3. When should the emergency bypass valve be opened?

4. What does the emergency bypass valve do?

644. Specify how to reservice air cylinders using the cascade method.

Reservicing Procedures (Cascade Method). When air cylinders are to be reserviced using the cascade method, you should proceed as stated in the following paragraphs.

Connect the manifold, charging hose, and gauge. Before opening any valves, check the pressure remaining in the cylinder to be filled. Then, open and close each valve on the large storage cylinders to find the one with the lowest pressure. If this storage cylinder has a pressure lower than the small cylinder, do not attempt to use it for filling. Use a storage cylinder that has a pressure higher than the small cylinder but lower than the other large cylinders.

Open the valve on the small cylinder. Then, open the valve on the storage cylinder with the lowest pressure only. When the pressure indicated on the two cylinder gauges become equal, close the valve on the storage cylinder, then go to the storage cylinder with the next higher pressure and repeat the procedure.

If, after using the last storage cylinder, the small cylinder is still not fully charged, a full storage cylinder should be put in place of the cylinder with the lowest pressure and used in the same manner. Make sure you close the cylinder valve on the small cylinder before disconnecting any manifold connection.

The procedure of cascading can be simplified and expedited by marking on each cylinder with chalk the remaining pressure in the cylinder. It is then very simple to select the cylinder and sequence to be used.

Exercises (644):

1. When reservicing air cylinders using the cascade method, what should be done before any valves are opened?

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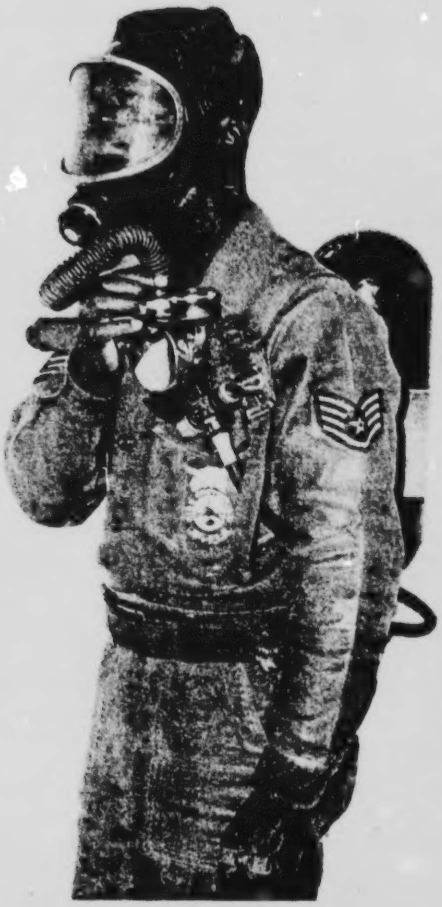

Figure 3-8. Connecting the face mask.

2. How do you find the storage cylinder with the lowest pressure?

3. Which of the storage cylinders should be opened first to reservice an air pack (small) cylinder?

4. If, after using the last large storage cylinder, the small cylinder is not fully charged, what should be done?

5. How can the cylinder and sequence selection be simplified?

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3-3. Handtools

The efficiency of any person doing a job is determined to a great extent by the tools he uses. Likewise, a fire protection specialist is judged by the manner in which he handles and cares for the tools he must use. Tools are a valuable aid in rescue operations. Just as in any other profession, there is a proper place for every tool, and each tool must be in its proper place to ensure immediate use in any emergency that may arise. Before tools are stored, they should be carefully inspected to see that they are serviceable, clean, and dry. If tools are not used frequently or are used in areas of high humidity, they should be covered with a light coating of preservative lubricating oil or SAE 10 engine oil to prevent rusting. To perform effectively as a fire protection specialist, you must know the handtools available and how they are used. Some of the common and special handtools used by fire protection personnel are discussed below.

645. State the uses and abuses of hammers, pipe wrenches, and screwdrivers.

Hammers. While there are many types of hammers available, the one primarily used by fire protection personnel is the ball peen hammer. The head should be kept clean and coated with oil as needed. The handle should be tight in the head; if it is not, replace it. Incorrect or abusive use of hammers frequently results in uneven face areas. To reshape worn faces, grind the face to its original shape.

Pipe Wrenches. Pipe wrenches, which vary in size, are used for tightening or loosening pipes and pipe connections. Common misuses of pipe wrenches are using the wrong size wrench for the size of pipe, using the wrench as a hammer, using the pipe wrench on nuts and boltheads, and using a "cheater bar" (length of pipe put on wrench handle to make it longer for more leverage). Pipe wrenches should be kept clean and lightly oiled. Keep the jaw-teeth clean and edged so that they will grip.

Screwdrivers. The most common type screwdrivers are standard, cross recess (Phillips), and offset. They are used for removing or placing screws. Common abuses of screwdrivers are using them as pry bars, chisels, or using the wrong size blade in screw heads. Care and maintenance consist of keeping screwdrivers clean of grease and grime, preventing rust, and maintaining the tips. In recent years, a new type of screwdriver (clutch head) has been introduced on the market.

Exercises (645):

1. What type of hammer is the one primarily used by firefighters?

2. What should be done with a hammer when the face becomes uneven?

3. What are the common misuses of pipe wrenches?

4. Why should the jaw-teeth be kept clear and edged?

5. What does the care and maintenance of screwdrivers consist of?

646. State the uses, abuses, and maintenance of pliers, wrenches, and chisels.

Pliers. Pliers are used for cutting small wires and bending or crimping tubes; they should not be used as pry bars or for removing nuts and bolts. Those commonly used are the adjustable combination pliers, half-round nose pliers, and round nose pliers. Keep pliers clean, lubricate their pivot pins, and coat them with oil as needed. There are several different types of pliers, each having a specific use.

Wrenches. These are available in many shapes and sizes, such as Allen wrenches, open end, box end, pipe wrenches, adjustable wrenches, and socket wrenches. Wrenches should be clean and free of dirt and grease, wiped dry with a clean cloth, and lightly coated with oil. Common misuses of wrenches are pushing instead of pulling on them, using the wrong size, using adjustable wrenches incorrectly, and using pipes (cheater bars) for excessive leverage.

Chisels. Although there are many types of chisels, the one most commonly used by firefighters is the machinist's cold chisel. Keep chisels properly ground, sharpened, and free from mushroomed heads at all times. Scour off all rust or corrosion and protect metal surfaces with a light coat of oil.

Exercises (646):

1. What should pliers NOT be used for?

2. What are commonly used types of pliers?

3. In what direction should pressure be applied to a wrench?

4. What type of chisel is most commonly used by firefighters?

5. How are the metal surfaces of chisels protected from rust or corrosion?

647. State the construction of pike poles, the uses and care of safety goggles, and uses of safety pins.

Pike Pole. The pike pole is a very useful and versatile tool. The pole itself (fig. 3-9) is made of wood or fiberglass with a metal pike and hook. Pike poles may vary in size from 6 to 12 feet in length. The most common length used in the Air Force is the 8-foot pole. It may be used to pull plaster and lath from a ceiling (fig. 3-10), to expose wiring, or make access to an attic or concealed area (fig. 3-11). The pike pole is also very helpful in opening windows. (See fig. 3-12.) You can also use it for punching holes through subceilings for ventilation (fig. 3-13) and for separating burned or burning materials where the heat is intense. When removing material from ceilings, use a pole that is long enough so that you do not need to stand under the material being removed. Also, pushing away and down on the pike pole handle while pulling it back through the hole will cause the freed material to fall away from you. You may find it convenient to have a painted spot or notch on the handle of the pole so that you can tell which way the hook is pointed even though the hook is out of sight in a hole. The hook can get caught if the pole is turned after pushing through a hole.

The pike and hook should be treated the same as any other edged or pointed tool. Some pikes and hooks are never edged but are allowed to remain in a dull, rounded condition. Be sure to lightly oil the pike and hook portion periodically to prevent rusting or corroding.

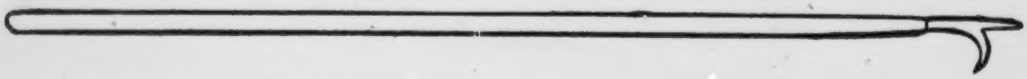

Figure 3-9. Pike pole.

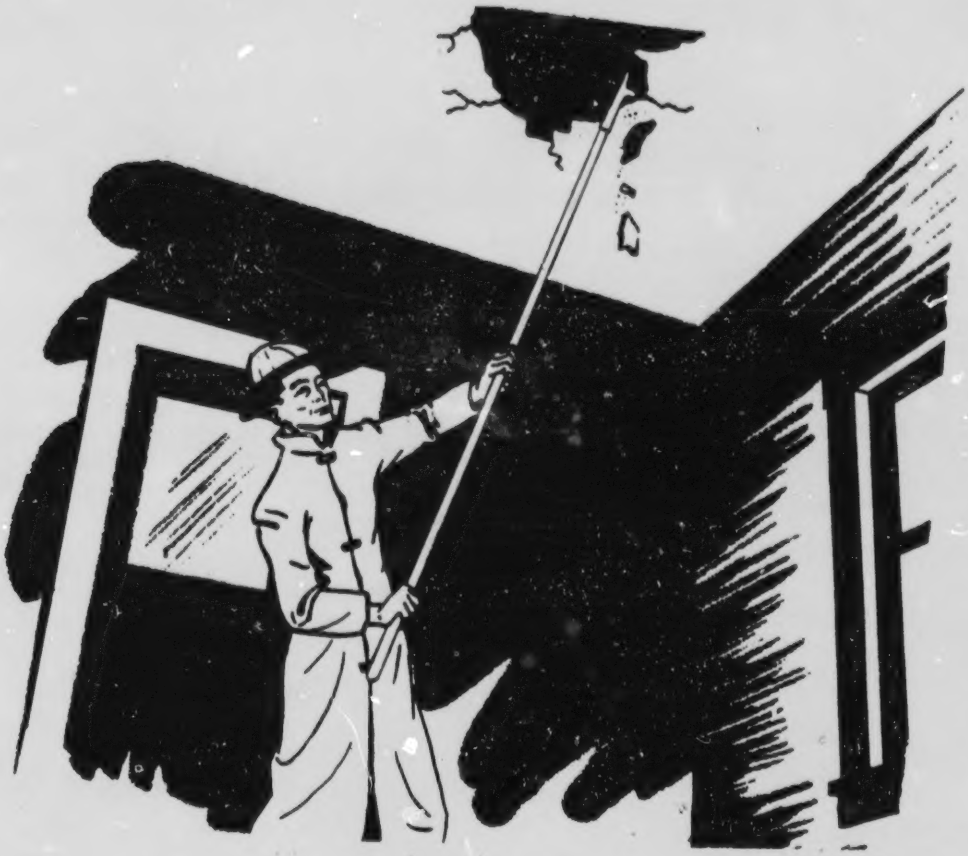

Figure 3-10. Removing plastered ceiling with pike pole.

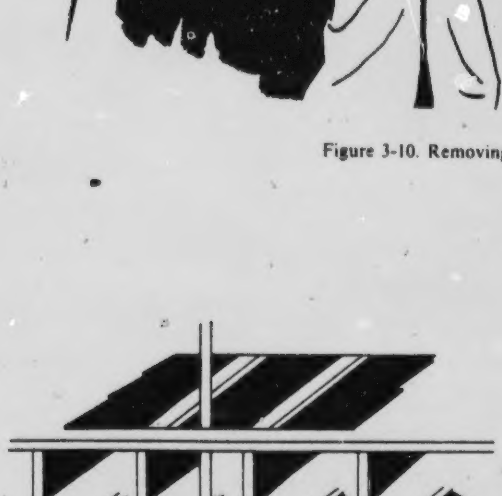

Figure 3-11. Making access to a concealed area with pike pole.

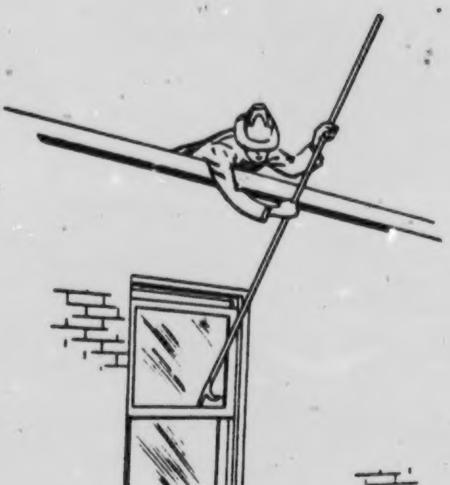

Figure 3-12. Using pike pole to open windows.

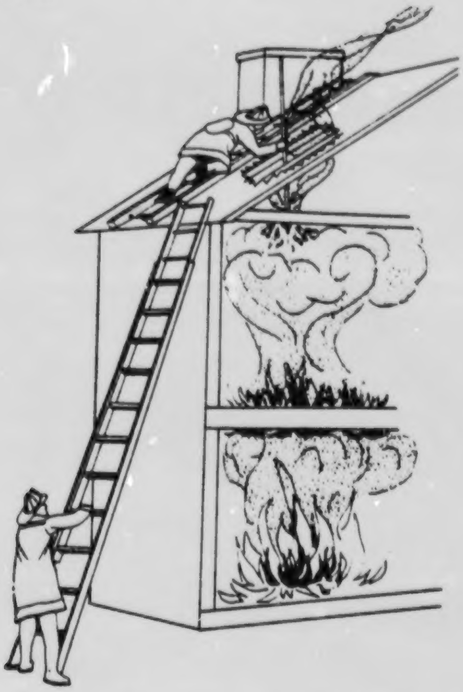

Figure 3-13. Extending ventilation opening.

Safety Goggles. Standard industrial goggles are included for personnel eye protection and must be used during all hazardous operations where damage to the eyes is possible. Do not allow oil or gasoline to contact goggles or crystallization will occur.

Safety Pins. There are several safety pins carried on the rescue vehicles, depending on the type of aircraft assigned to your base. These pins are to be used to prevent accidental firing of escape systems and to further safety the egress systems in aircraft. In addition, the safety pins supplied with the vehicle may also be used with salvage covers.

Exercises (647):

1. What is the pole of a pike pole constructed of ?

2. What is the most common length of pike pole used in the Air Force?

3. When should safety goggles be used?

4. Why should safety goggles be kept out of contact with gasoline or oil?

5. What is the purpose of safety pins?

648. State the uses and limitations of Dzus keys, cable cutters, and pick-headed fire axe.

Dzus Keys. A special tool called a Dzus key is used to open various compartments and access panels that are kept closed by Dzus fasteners. They provide a fast and easy method of access to compartments of an aircraft.

Cable Cutters. Cable cutters (fig. 3-14) are designed to cut up to a 3/8-inch wire or cable. Each handle is rubber-covered and designed to protect you from electrical shocks up to 14,000 volts. Attached near and in front of the jaws is a set of hooked horns. These horns are more or less in a V-shape. The V-shape will help guide the particular wire you wish to cut into the cutting jaws. The horns are hooked at the end and are also designed to assist you in moving or removing a "hot" (electrically charged) line. Some cable cutters may not come equipped with these hooked horns. If you apply a light coat of oil to moving parts and the jaws, remove any corrosion with emery cloth, and use the tool properly, then a visual check of condition daily and a periodic check for operation will be enough for this tool to give you many years of outstanding service.

Pick-Headed Fire Axe. One of the most useful of all the tools mentioned in this chapter is the pick-headed axe (fig. 3-15), commonly called the Firefighter's Friend. The axe head weighs only 6 pounds, which will not quickly tire the user. It can be used for prying open doors and windows, cutting flooring, opening roofs for ventilation, smashing window panes safely by keeping your back to the wind (fig. 3-16), removing hinge pins (fig. 3-17), and pulling lath and plaster.

In cutting with an axe, use short, quick, forceful strokes for better aim. This prevents the axe from striking nearby personnel or from catching in overhead obstructions. This method of cutting is particularly important in dark and smoke-filled areas.

Cuts are made diagonally rather than with the grain of boards and as close to a joist or stud as possible. A proficient firefighter should be able to use the axe both right- and left-handed. Cutting in difficult corners and under obstructions with the axe can be efficiently done only after proper demonstrations and practice—practice—and more practice. Cuts in flooring, roofing, or sheathing should be made at an angle of about 60°, as you can see in figure 3-18, instead of

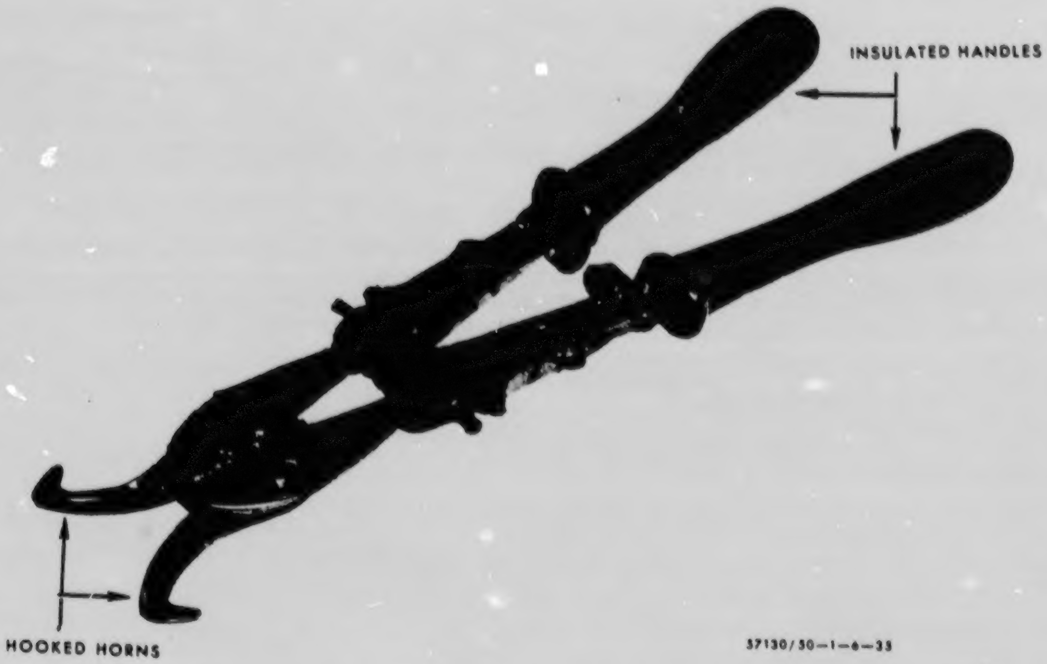
INSULATED HANDLES
HOOKED HORNS
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Figure 3-14. Cable cutters.

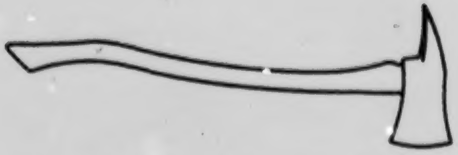

Figure 3-15. Pick-headed fire axe.

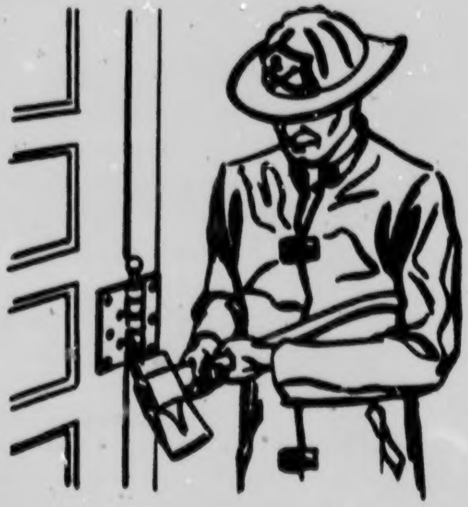

Figure 3-17. Removing hinge pin.

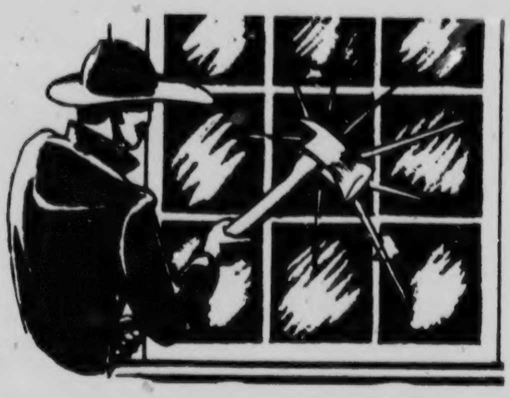

Figure 3-16. Breaking window glass with axe.

straight across. Diagonal sheathing is also cut slantwise to the grain of the wood so that chips will tend to split out. If your cuts are made with the grain of the sheathing, the axe may bind and require extra effort and time to withdraw it. Your cuts through lath-and-plaster walls are made in a direction diagonal to the run of the lath rather than perpendicular to it. After the boards are cut, you can use the pick end of the axe for prying and removing boards, as shown in figure 3-18. You will soon learn to make cuts near to a heavy beam or wall stud rather than centered between them. This is to reduce the springy give and bounce that you get if you strike an unsupported lath or board.

Exercises (648):

1. What are Dzus keys used for?

2. What are cable cutters used for?

3. How thick of a piece of material will the cable cutters cut?

4. The cable cutters have a rated insulation resistance of __________ volts.

5. When cutting with a pick-headed fire axe, how should you make the cuts?

6. What may happen if cuts are made with the grain of the wood?

649. State the uses and construction of the de-arming tool, plugs, and the harness cutter.

Ejection Set Catapult Hose Cutter (De-Arming Tool). This hose cutter is designed to cut the hose that leads from the catapult initiator to the catapult explosive charge or device used on an aircraft to jettison the ejection seat or capsule. Figure 3-19 shows two handles, a hook, and a sliding shaft. The hook is used to keep the hose in position while the handles are brought together, thus causing the shaft to slide to the

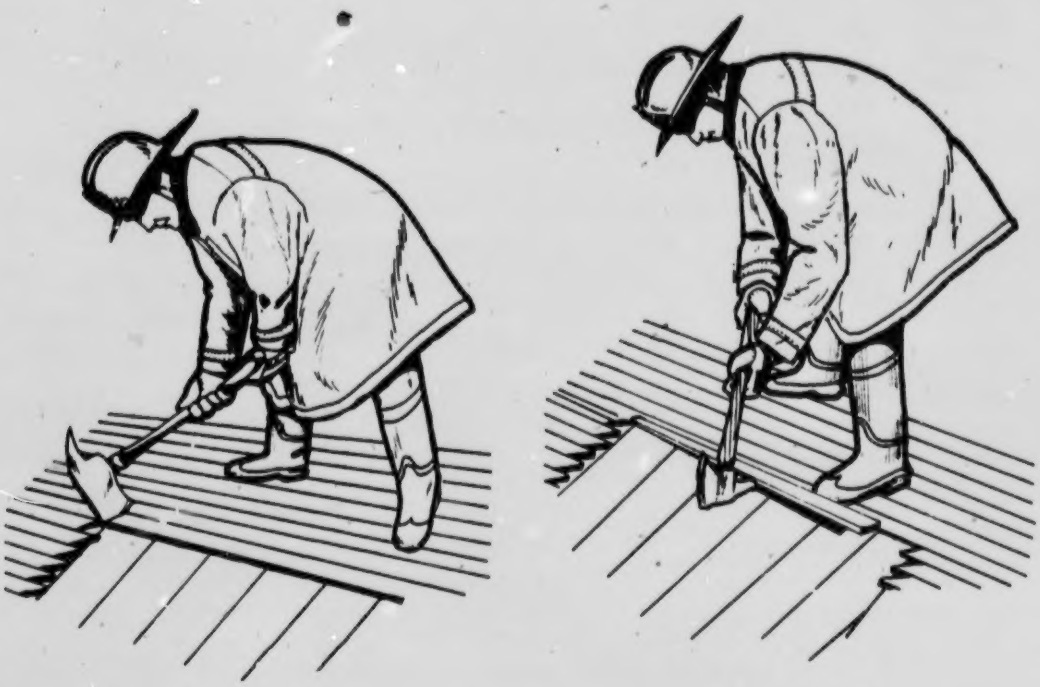

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Figure 3-18. Angle cutting in wood floor.

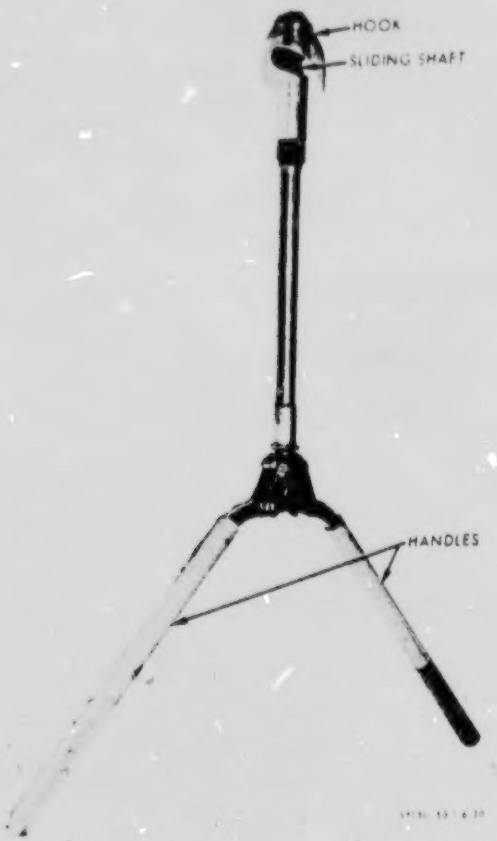

Figure 3-19. Ejection seat catapult cutter.

hook. Approximately 1 inch of the hose is cut from the rest. Even after the piece is cut out of the hose, the cut ends should be bent away from each other to prevent possible accidental jettisoning of the seat. This will be discussed in greater detail in a later volume.

Many parts of the hose cutter are of cast aluminum and need no more maintenance than a light oiling of the sliding shaft. A daily visual check and an operational test for free movement will be enough to make sure that everything on the tool is in working condition.

Plugs. Oil resistant, hard rubber plugs and hardwood plugs are conical in shape and approximately 8 inches in length. These plugs are used for plugging fuel and hydraulic lines and/or leaks.

Harness Cutters. Harness cutters, also called the "V" blade knife, have two converging steel blades for ease in cutting seat belts and harnesses to release accident victims.

Exercises (649):

1. What is the de-arming tool designed to do?

2. What is the hook on the de-arming tool used for?

3. What are plugs made of?

4. What shape are the plugs used to plug fuel lines?

5. How many blades are in the "V" blade knife?

650. Specify the construction, uses, limitations, and maintenance of the crash axe, bolt cutters, and crowbar.

Crash Axe. The crash axe is extremely heavy for its size. Its primary purpose is to cut through the metal skin of aircraft. The blade is so shaped as to not have a corner to jam or stick in the cut. Figure 3-20 shows that each side of the blade has a stop which prevents it from passing completely through aircraft metal skin. The handle is insulated to protect you against as much as 20,000 volts of electricity, but do not let this feature make you careless. Use the crash axe by directing the blade straight at the aircraft skin. After the initial cut, slice the skin with successive short cuts until the opening required is large enough for your purpose. A light oiling of the blade will prevent corrosion or rust, and a protective covering of neat's-foot oil on the rubber handle will keep it in shape. You must use extreme care when sharpening this blade so as not to grind it too thin. We suggest that this tool be sharpened only by personnel who have had special instruction and experience in the sharpening of fire and crash axes.

Bolt Cutters. You can see by a study of figure 3-21 that this tool is heavy and somewhat cumbersome to handle. Bolt cutters are designed to cut any rod or bolt up to 5/8 inch in diameter, except specially hardened bolts or rods. By moving the handles away from each other, the jaws are opened; bringing the handles together closes the jaws. The jaws are capable of opening and receiving a larger bolt than 5/8 inch, but the handles are then so far apart that one person cannot exert enough leverage to cut the bolt.

To prevent excessive free play, the tightening bolts should be adjusted periodically. Apply a light oil at each moving part and to the jaws. The jaws should never be sharpened except by a person who has been specially trained to do the job. The handles are usually painted to keep down corrosion. The daily visual check should be made to make sure that no corrosion is present on any portion of this tool. Improper use, such as trying to cut hardened steel, will cause the jaws to become dented or chipped.

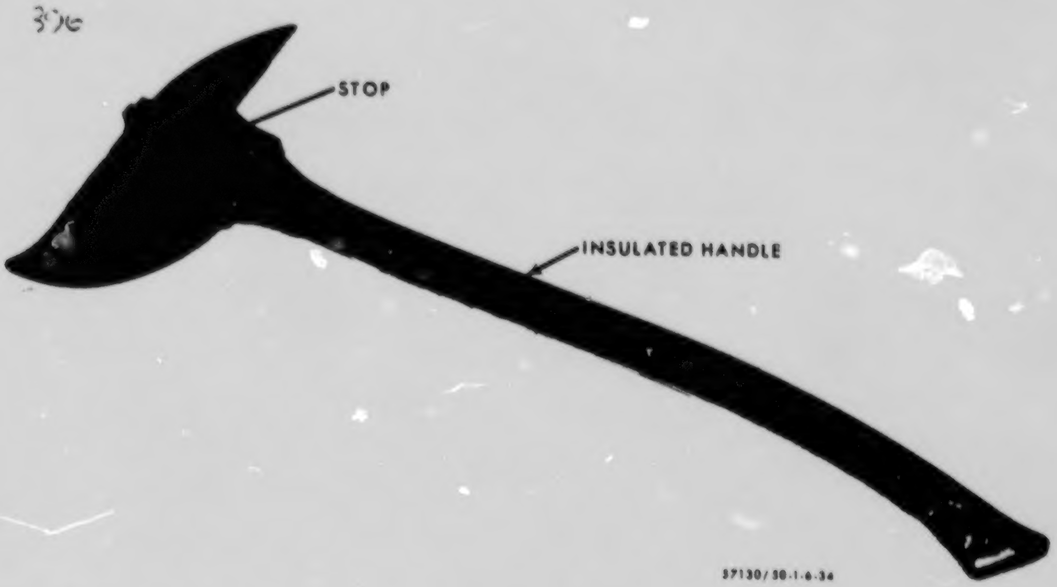
STOP
INSULATED HANDLE

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Figure 3-20. The crash axe.

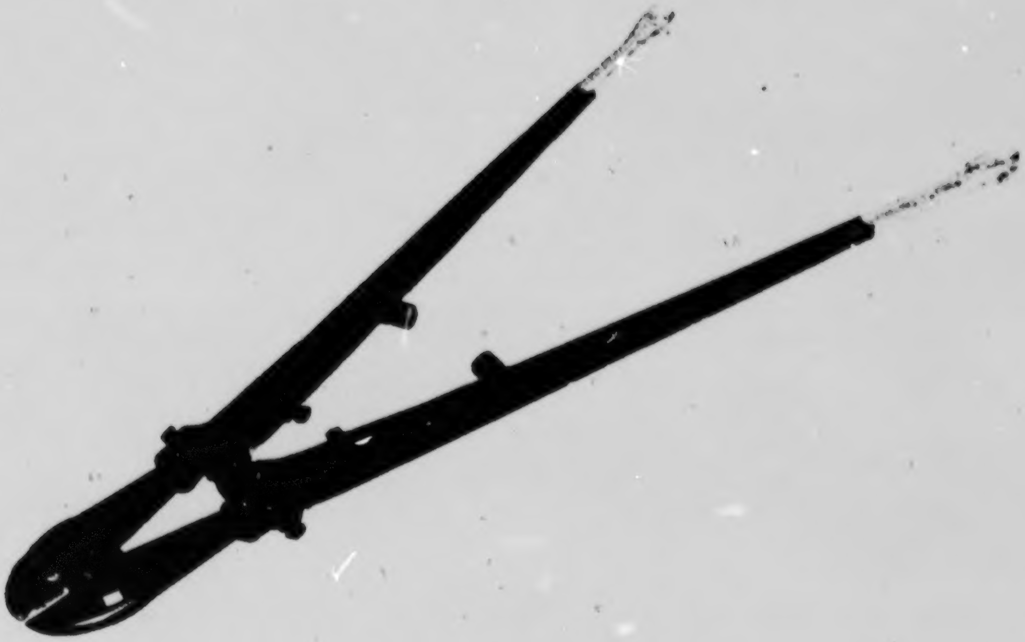

Figure 3-21. Bolt cutters.

Figure 3-22. The crowbar.

Crowbar. The crowbar (fig. 3-22) must not be mistaken for the clawbar carried as a special tool on some rescue trucks. The crowbar is used for forcible entry in cases requiring heavy prying or great strength. It can be used to efficiently and quickly tear away lath and plaster for the purpose of eliminating fire spread or locating the source of the fire. Metal and composition roofs or ceilings may also be opened with this heavy-duty tool.

Maintenance of this tool is extremely simple. You need only to check for signs of rust or corrosion, check for the condition of the edge, and determine whether or not it has been bent due to excessive strain. That such a thing should happen to this durable tool seems unlikely; but, if it is bent, turn it in rather than trying to straighten it.

Exercises (650):

1. Why is the blade of the crash axe shaped the way it is?
2. What prevents the axe blade from passing completely through the metal skin of an aircraft?
3. What should you use to keep the handle of a crash axe in shape?
4. What size rods or bolts will the bolt cutters cut?
5. How is excessive free play in the jaws of the bolt cutters prevented?
6. What will cause the jaws of the bolt cutter to become chipped or dented?
7. What other tool is the crowbar mistaken for?
8. When is the crowbar used?
9. If the crowbar becomes bent, what should be done with it?

651. State the uses and design features of the door opener and the pry axe.

Door Opener. This tool may be called a wrecking bar in some areas, but it is more commonly known as the door opener. The design features include a tapered hook, battering knob, and claw. These features are easily recognized in figure 3-23. The length of the bar from tip to tip is about 43 inches, and the weight is sufficient to give plenty of force to any task. Figure 3-24 shows the hook being used to pry out the staple of a door hasp. Of course, this is only one of the many uses which may be found for this tool. The battering knob gives itself away by its name and is quite helpful in quickly battering a door open. The claw can be used to pry open small and large doors or to remove nails or spikes.

If you use it properly, this tool will require a surprisingly small amount of maintenance. The tapered tip is the part that receives the most wear. Damage is done by using the thin part of the tip for heavy prying or pulling tasks. Caution must be used when you are working with this tapered tip, since the point is quite sharp. A light oiling periodically and removal of corrosion should be all that is required to keep this tool in excellent condition. Note, however, that you should never oil a tool to the extent that a handhold may be slippery.

Pry Axe. The pry axe is one of the most versatile tools available to you. The very design of this tool is such that it may replace several of the other handtools in use. Within this one tool, you have the same basic features of the door opener, crowbar, and hatchet. The pry axe may also be used as an impact tool by virtue of the sliding head/handle arrangement. The claw section of the tool may be removed from the head section and inserted in the side of the head for leverage.

A light coat of oil on the metal parts will protect them from rusting. Be sure to check the edged and pointed sections to insure that they are not damaged and/or blunted.

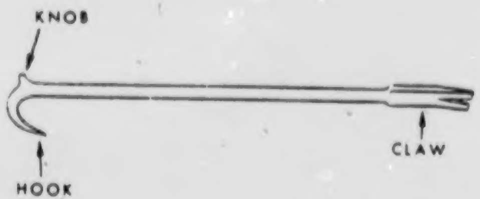

Figure 3-23. The door opener.

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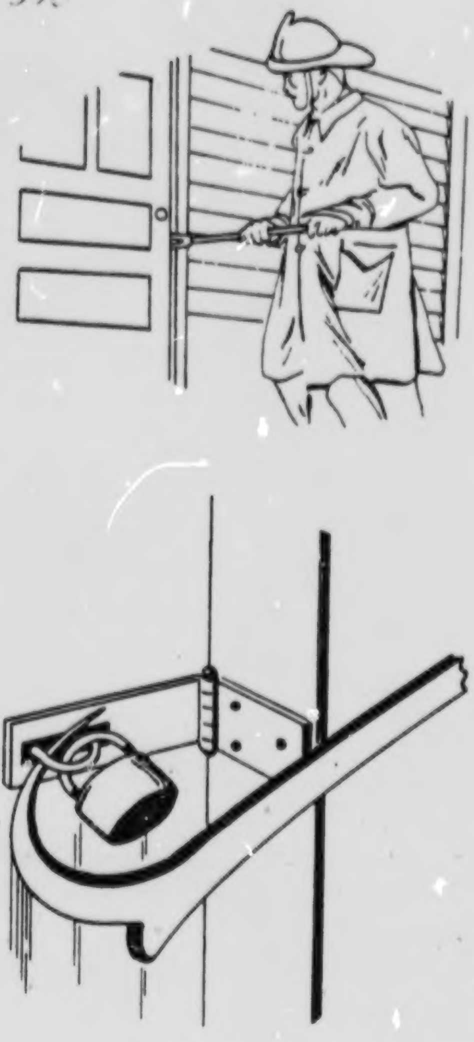

Figure 3-24. Using a door opener.

Exercises (651):

1. What part of the door opener would you use to pry the staple out of a door hasp?

2. What part of the door opener receives the most wear?

3. How is the door opener damaged?

4. The pry axe has the design features of what three tools?

5. How can you get additional leverage on the head of a pry axe?

3-4. Power Tools

Without power rescue tools, forcible entry could not be made at all in some cases. There are times when hand rescue tools will not do the job. Your rescue vehicle comes with the basic power equipment needed. This equipment requires a little more maintenance and care, but it is well worth it when you need power assistance.

652. State the power output of the portable generator and the precautions to take when using it, and identify the accessories necessary to its effective use.

Portable Generator. The generator discussed here is of the type supplied with earlier model rescue vehicles. Be sure to check the TO for the specific make and model you will be working with.

The portable generator is provided to supply lighting at the scene of an accident or incident. It is governed at 3600 rpm, produces 1000 watts of power, and discharges 8.7 amps at 115 volts. This current operates the flood lamps. The generator should not be started with the lamps plugged in. If a load is on the generator, it is extremely hard to start. The generator is air-cooled and must be provided with sufficient circulation of air to prevent overheating. It must be operated on a level surface. If operated on an incline, the engine may be damaged by increased wear, legs may be worn from vibration, or generator parts may be broken off if it falls on its side. After use, care must be taken when transporting it so that personnel will not be burned on the exhaust unit of the cylinder housing.

Portable Lighting Equipment. Quartz-iodide floodlights are provided for use in illuminating areas where a stationary electrical power and lighting facilities are not available. These lights are powered by a portable generator and have vertical direction and focus adjustments to ensure proper lighting of the work area. Two 50-foot extension cords and a "Y" connector are furnished to connect the floodlights to the generator. The cords and connectors are equipped with twist-lock connections which have rubber boots for watertight connections.

Exercises (652):

1. What is the power output of the portable generator?

2. Why should you not try to start the generator with the lights plugged in?

3. What will happen if the generator is not provided with sufficient circulation of air while it is in operation?

4. What type of floodlights are provided for use with the portable generator?

5. How long are the extension cords used with the flood lights?

653. State the uses and work capacities of the engine-driven blowers and hydraulic ram kit.

Engine-Drive Blowers. Blowers are primarily used to remove smoke and fumes from enclosed areas. A blower consists of a large fan, driven by a one-cylinder, two-cycle gasoline engine mounted in a steel frame. This unit operates at a fixed speed of between 2000 and 2400 rpm at 2.75 horsepower. The oil and gasoline mixing ratio is 1 to 10. It has a tank capacity of 1 quart.

Hydraulic Ram Kit. The ram and pump kit is a hydraulically operated unit, used in emergency rescue operations, to raise objects in order to remove trapped personnel, or to spread parts during rescue operations. (See fig. 3-25.)

The unit has a pump (hydraulic) with high-pressure hose to withstand the 11,000 pounds of force applied to the ram kit. The piston has a reach of 6 inches.

Exercises (653):

1. What are the engine-driven blowers primarily used for?

2. The engine-driven blowers have a fixed speed of how many RPM?

3. What is the oil and gasoline mixing ratio for the engine-driven blowers?

4. What is the hydraulic ram kit used for?

5. What is the capacity of the hydraulic ram kit?

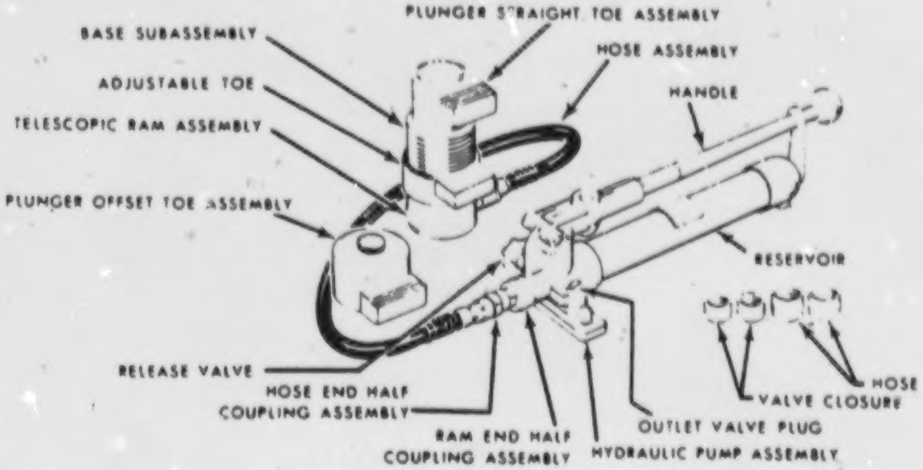
PLUNGER STRAIGHT TOE ASSEMBLY
BASE SUBASSEMBLY
HOSE ASSEMBLY
ADJUSTABLE TOE
HANDLE
TELESCOPIC RAM ASSEMBLY
PLUNGER OFFSET TOE ASSEMBLY
RESERVOIR
RELEASE VALVE
HOSE END HALF COUPLING ASSEMBLY
HOSE
VALVE CLOSURE
OUTLET VALVE PLUG
RAM END HALF COUPLING ASSEMBLY
HYDRAULIC PUMP ASSEMBLY

Figure 3-25. Hydraulic ram and pump kit.

654. State the power sources, size, work capacity, and method of customization of the Hurst tool.

Hurst Tool (Jaws of Life). The portable Hurst power rescue tool provides 10,000 pounds of usable force to rescue trapped victims in an accident situation. The unit consists of an engine and hydraulic pump mounted on a common frame. The pump provides power to the rescue tool. It is connected by two high-pressure hoses with quick-disconnect couplings. The engine and pump weight is 40 pounds. Its dimensions are 17" x 18" x 11". The tool has a weight of 55 pounds and dimensions of 6½" x 14½" x 31". This tool is capable of exerting 5-ton pressure at the arm tips. It is completely portable and can be operated at any altitude. The controls for opening and closing the arms can be operated by thumb pressure from either hand. The arms have a 32" travel from CLOSED to fully OPENED positions. Opening and closing time for the jaws or arms is 11 seconds with no load and 40 seconds loaded. The arms can be used as spreading or pulling devices. In addition, the tool is furnished with special heads which fit on the arm tips. They provide for cutting, slitting, shearing, or piercing.

The arms or jaws are constructed of forged titanium that can pull or lift 5 tons to free trapped victims. Some of the features of the Jaws of Life are listed below.

- Operates in any position—safely and swiftly.
- Requires only thumb pressure for one-man operation.
- Offers 10,000 pounds of usable, lifesaving force.
- Features quiet hydraulic operation that is flameless and free of spinning blades or wheels.
- Can raise a car, roof, steering column, or dash and can remove doors.

The tool has lifesaving applications in aircraft personnel rescue, surface TRANSPORTATION systems (railroad, buses, etc.), and a variety of industrial and commercial rescue areas. Capable of exerting 5 tons of force at the jaw tips, it is the ideal rescue tool for automotive, aviation, marine, mine, farm, or industrial rescue. Using special application snap-on jaws, this rescue tool is instantly customized to spread, cut, slit, shear, or pierce—above all, to rescue.

Exercises (654):

1. Power is provided to the Hurst rescue tool by what means?

2. What is the combined weight of the pump, engine, and rescue tool?

3. The Hurst tool is capable of exerting how much pressure at the arm tips?

4. How are the controls for opening and closing the rescue tool arms operated?

5. How is the Hurst tool customized for specific jobs?

655. Specify the uses of the air chisel and porto-power tools.

Air Chisel. The air chisel is a little-known rescue tool that is of great value when properly used. It is very portable and requires only compressed air for power. Its use is not necessarily over when its air supply is exhausted, because it may be attached to a breathing apparatus air bottle.

This tool is very useful for cutting thin metal, etc. As the name implies, it is a chisel driven by air power instead of a hammer.

Porto-Power (Model RS 10 Extricator). This indispensable rescue tool has been field-proven for emergency extrications. You can use it for pushing, spreading, or bracing. A common application is to use the Wedgie (small jaws) and spread rams with separate pumps to open doors of damaged vehicles. However, the extricator set provides much more versatility to effect fast and efficient rescues. The simple bail hook picks off chrome window moldings in seconds—the heavy duty knife cuts the rubber gaskets on windshields and back glasses in seconds. The powerful "come-along" is anchored to a frame member and can be used to pull entire seats and steering columns which have pinned victims inside the car due to the impact. Other useful components include a hacksaw, aircraft quality snips, wrenches, screwdrivers, pliers, and a pry axe. It must be emphasized that this set is professional in every respect for automotive, as well as industrial, rescue use. It has been used most successfully by rescue squads and will, by far, outperform crowbars, cutting torches, winches, etc. The extricator was designed for use by professionals who know their business. Study it before you use it.

Exercises (655):

1. How is the air chisel powered?

2. Suppose that, at the scene of an accident, the compressed air tank for the air chisel is emptied. What, in most cases, will be used for power?

3. How is the Porto-Power used for rescue operations?

4. If a victim is pinned in a pickup truck by the steering wheel, how would you use a Porto-Power tool to free him?

656. Specify the uses, makeup, and maintenance of the K-12 saw.

K-12 Power Rescue Saw. The K-12 power saw and related accessories are conveniently packed in the carrying case for ready use. The saw is powered by a two-cycle, gasoline engine that develops 6 horsepower at 6000 rpm and can operate in any position. The fuel tank is fitted with special suction felt so that the engine can be run to the last drop of fuel independent of the position of the machine. Power is transmitted to the blade cutter by means of a belt and pulley arrangement. The pully belt has a fiberglass reinforcement for better durability. The saw has a light alloy frame with side guards for the belt. Drive belt tension is adjusted with adjuster screws. A support flange attaches the blade cutter to the cutting attachment drive shaft. Three types of blade cutters are provided for faster cutting in any material—carbide tip, metal, and concrete. Blades are especially designed for the high speed and rough use needed in forcible entry operations. The power saw blade guard covers much of the blade cutter to protect the operator from flying chips and dust. The guard lock knob locks the blade guard in its correct working position.

A pull-cord-type starter is used with an automatic return and a device which engages with the engine crankshaft. The control switch is a combined accelerator and clutch type, and it functions with automatic return to idle speed when the grip is released. The stop buttom is conveniently located close to the throttle control, as is the choke arm. The carrying handle is coated with a fluted polythene to provide good grip. The air cleaner has a replaceable paper element for maximum cleaning of induction air. The spark plug is encased for protection from snow and water. The silencer muffles the sound and protects the operator from exhaust gases.

Fuel mixture is critical in the K-12. The engine is lubricated with a mixture of oil in the fuel. Four percent oil is mixed in the gasoline for this purpose (1 to 25 ratio). The fuel tank has a capacity of 1 quart.

This saw is vital to many rescue situations, but to operate it properly requires training in the techniques of cutting. With each type of material being cut, there is a different cutting method employed. Refer to TO 36A12-12-13-1 or TO 36A12-12-13-11 for complete operating instructions.

Exercises (656):

1. What is the rated power of the engine on the K-12 saw?

2. What is the purpose of the belt and pulley assembly on the K-12 saw?

3. What are the three types of blade cutters provided with the K-12 saw?

4. How is the engine of the K-12 saw lubricated?

5. In what publication(s) will you find the complete operating instructions for the K-12 saw?

657. Specify the uses and abuses of the Target power saw.

Target "Quickie" Power Rescue Saw. The Target Quickie is another rescue saw, gasoline driven, that is comparable to the K-12. It is heavier than the K-12 and usually easier to start.

Engine life depends on the proper fuel mixture—the right grade of gasoline and the right type of quality oil, both in proper ratio. Efficient operation and proper lubrication of the engine's internal moving parts depend on it.

Gasoline. Only regular grade gasoline of a low lead content should be used. Continued use of gasoline of a high lead content will result in poor performance and the formation of lead deposits in the combustion chamber and on the spark plug.

Oil. McCulloch 40/50 oil is recommended. Never use automotive or reclaimed motor oils.

Mixture. Refer to the following guide, and mix gasoline and oil in proportions indicated in the fuel mixture guide below. Using less oil than specified will cause overheating of the engine and may damage the engine parts. If too much oil is used, the engine will run unevenly, the oil may foul the spark plug, and power loss can result.

Using a separate container with a flexible spout and strainer, thoroughly mix enough fuel for not more than a day's operation. Stored fuel will collect moisture and lose strength, resulting in poor engine performance.

WITH McCULLOCH 40/50 OIL (40 TO 1 RATIO)

GASOLINE	*OIL*
2 U.S gallons	1 (6 oz) can
1½ Imperial gallons	1 (6 oz) can
7 liters	1 (6 oz) can
5 U.S. gallons	1 (16 oz) can
4 Imperial gallons	1 (16 oz) can
19 liters	1 (16 oz) can

WITH SAE 40 TWO-CYCLE MOTOR OIL (16 TO 1 RATIO)

GASOLINE	*OIL*
1 U.S. gallon	½ U.S. pint
1 Imperial gallon	½ Imperial pint
4 liters	¼ liter
2 U.S. gallons	1 U.S. pint
2 Imperial gallons	1 Imperial pint
8 liters	½ liter
4 U.S. gallons	1 U.S. quart
4 Imperial gallons	1 Imperial quart
16 liters	1 liter

Exercises (657):

1. What does the engine life of a Target rescue saw depend upon?

2. The continued use of high lead content gasoline will have what effect on the engine of a Target rescue saw?

3. What type(s) of oil should NEVER be used in the Target saw engine?

4. If too much oil is mixed with the gasoline for use in the Target saw engine, what will happen?

5. Why should you mix only enough fuel for what is needed for one day's operation?

6. When using SAE 40 two-cycle motor oil for the Target saw, how much gasoline should be mixed with 1 U.S. quart of oil for the proper ratio?

658. Specify the makeup and testing of the electric power saw.

Electric Power Portable Saw. Figure 3-26 shows a typical circular motor handsaw that can be held in the hand while it performs its sawing operations. The blade is protected at all times by a spring-loaded guard sheath. This sheath can be locked in the retracted position for certain cutting jobs requiring it, but it must never be allowed to remain retracted. An extra handle is provided alongside the trigger housing to give two-handed stability as you guide and apply force to the cut. The blades for this saw come in 6- and 8-inch sizes. These are special blades designed to cut metal or masonry.

Be sure to keep the electrical windings and other parts of the motor clear of any moisture or accumulated dust or dirt. This will give extra life to the motor. Test the spring on the retractable guard for its spring tension. Check to see if the trigger housing and the extra handle are securely mounted. If the blade is the type with teeth, check to see if teeth are missing and to make sure that they are not worn. Apply a light coat of oil to steel blades. Be sure not to place your hands on the blade unless the unit is unplugged. Sight-check the cable for breaks and wear. All of the above checks, plus an operational test, are usually performed daily.

Safety. Even though the power saws described are vital to rescue personnel, they are also extremely hazardous in the hands of the untrained. The following list is some of the safety rules that should be observed when operating the saws.

- Always use protective goggles.
- Wear adequate clothing.
- Make sure that no one is ever in front of the blade cutter at any time that the cutter is in operation.
- Use a special breathing device when cutting asbestos material, metal coated with red leaf, or stone which produces large quantities of dust.
- Never operate the power saw in contaminated areas without adequate fire protection equipment and clothing.
- Never start a new blade in an old hole.
- Never run the engine or motor full force without a load.
- Do not start or run the saw in an explosive atmosphere.
- Never touch, or try to stop, a moving blade with your hand.
- Be sure of your footing when operating your saw.
- Hold the saw with both hands at all times.
- Keep your saw clean.
- Keep the spark arrester in good condition and never run the engine without it (for gasoline engine saws).
- Do not smoke while using the saws.

Exercises (658):

1. How is the blade protected on the electric saw?

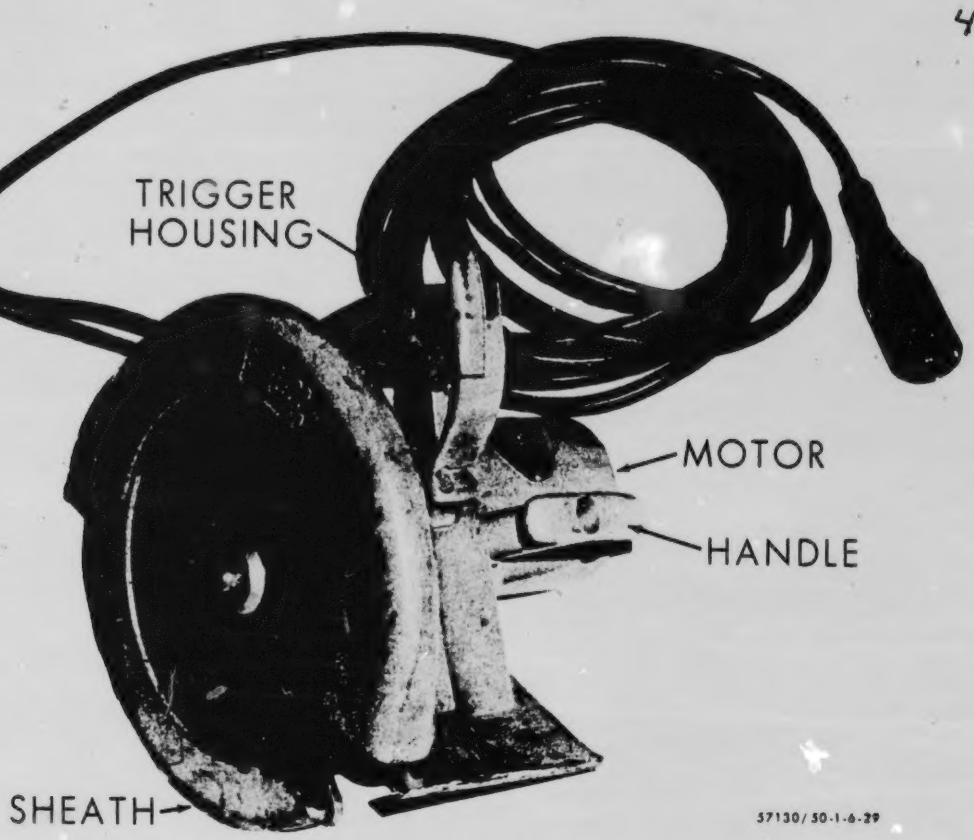

Figure 3-26. Electric power saw.

2. What is the extra handle for on the electric saw?

3. What sizes are the blades for the electric saw?

4. How often is the electric saw usually given an operational test?

3-5. Structural Rescue

The purpose of locks and fasteners is to protect property against intruders, but these devices may become an obstacle to rescue personnel responding to an emergency. A locked building requires forcible entry; however, it must be remembered that doors and windows may not be locked. You should always try to open them before you use force.

659. State the sequence of attempted entry into buildings.

Immediate action may be necessary to perform rescue, and a fire chief may assign a part of the personnel and equipment to take action before there is an opportunity to survey an entire situation. This action may be termed "the initial decision" from which a definite course of action may be formed. An initial decision is the first step toward a well organized plan and all rescue personnel should be assigned in compliance with this plan. Since size-up is a continuous mental operation, conditions and facts may change a previously made decision. These supplemental decisions are sometimes required to deal with new developments as they appear.

The degree of urgency presented by the situation will determine your actions to a large degree at the scene of the emergency. You must perform your duty as quickly and efficiently as possible. You have previously learned that you must always try the normal means of ingress first. The normal entrance door(s) is readily available to you and should be considered your primary means of entry. If the normal entry doors are locked or for some other reason cannot be used, check for another door, such as garage door or a basement entry door. When these are also locked, check for an unlocked window. If there is neither an unlocked door nor an unlocked window, you are going to have to gain entry forcibly. In this case, a window will provide the easiest and fastest means of entry. It is also easier and less expensive to repair. In the event that neither doors nor windows can be used, next you try roofs and then walls.

Doors, windows, floors, and roofs of different types are used for entrance to buildings or areas within a building. The construction features of some doors render them practically impossible to force open; therefore, entry may be more easily made by some other means. In this section, we will find several styles of doors and windows that will cause problems when you are trying to gain entry to a building.

Exercises (659):

1. What is considered the primary means of entry into a building?

2. What should you do if all doors into a building are found to be locked?

3. When all doors and windows are found locked, how will entry be gained?

4. In what sequence should you attempt forcible entry?

660. Specify the construction of common, panel, and ledge doors.

Common Doors. A firefighter must understand the various types of doors before he can make successful forcible entry. The doors normally found on air bases are metal doors such as ledge or batten, overhead rolling, slab, and industrial doors. The method of gaining entry through a door is determined first by the manner in which the door is hung and second by how it is locked. The construction features of some of these doors render them practically impossible to force, and entry may frequently be more easily made by some other means. You should first try the door to see if it is locked. If it is, determine the way it swings and what method of forcible entry will be effective.

Panel Doors. Panel doors may have horizontal or vertical panels, or a combination of both (as shown in the upper half of figure 3-24), with the panels made of thin material. The locks can be either surface or recessed, and the hinges can be mounted on the surface of the door or installed in the door itself.

Ledge Doors. Ledge doors, sometimes called batten doors, are found on warehouses, storerooms, and barns. They are made of built-up material and are locked with surface locks—hasp and padlocks, bolts, or bars.

Exercises (660):

1. Why must a firefighter have a knowledge of the various types of doors?

2. How do you determine the method of gaining entry through a door?

3. From a firefighter's point of view, what is the first step in forcible entry through a door?

4. How are the panels installed in panel doors?

5. Where are the hinges mounted on panel doors?

6. Where are ledge doors normally found?

7. How are ledge doors normally locked?

661. State the construction and hazards of sliding doors and the recommended procedures for forcing one open.

Sliding Doors and Forcing Techniques. Sliding doors are generally considered to be those which can travel either to the right or left of the opening while remaining in the same plane. Sliding doors are usually supported upon a metal track, and their side movement is made easier by small rollers or guide wheels. The ordinary sliding door travels into a partition or wall when it is pushed open. From a forcible entry point of view, the sliding "patio-door" presents the most hazardous situation. These units consist of heavy duty, full panel glass that is set into a metal frame. The glass panels are sometimes doubled or "thermopane," which adds to their value. Patio sliding doors usually slide past stationary glass panels instead of disappearing into a wall. Breaking these glass panels to gain entrance is not recommended. Sliding patio doors can, however, be forced open by inserting a wedge tool between the jamb and door, near the lock, and prying the door away from the frame as with other sliding doors.

Exercises (661):

1. How are sliding doors usually supported?

2. What type of sliding door presents the most hazardous situation, from a forcible entry point of view?

3. How do you force a sliding door?

662. State how to force doors that open toward you.

Forcing Doors That Open Toward You. The door hinges and jambs should be checked to determine the direction the door swings. If the door opens toward the firefighter, it must be forced in a certain manner. Several forcible entry tools may be used for this operation. The techniques of their use are similar. The steps are as follows and as shown in figure 3-27.

Step 1. Insert a blade of the tool between the door and jamb (fig. 3-27, item a) near the lock (upper half of fig. 3-24).

Step 2. Force the blade in and against the rabbet or stop by working and pushing on the tool. (The tool may be hammered with another object). (See fig. 3-27, item b.)

Step 3. Pry on the tool bar away from the door to move the door and jamb apart. (See fig. 3-27, item c.)

Step 4. Pull the door open or pry it open with another tool when the lock has cleared the keeper. (See fig. 3-27, item d.)

Exercises (662):

1. How do you determine the direction in which a door opens?

2. Where is the blade of the tool placed to open a door that opens toward you?

3. In which direction should the tool bar be moved to pry the door and jamb apart?

4. How is the door opened once the lock has cleared the keeper?

663. State how to force doors that open away from you.

Stopped Frame. If the door is in a stopped frame, the blade of the tool may be inserted between the stop and the jamb, the stop lifted, and the tool inserted between the door and jamb. By separating the door away from the jamb, the operator may spring it sufficiently to permit the bolt to pass the keeper. It may be better in some cases to remove the stop completely.

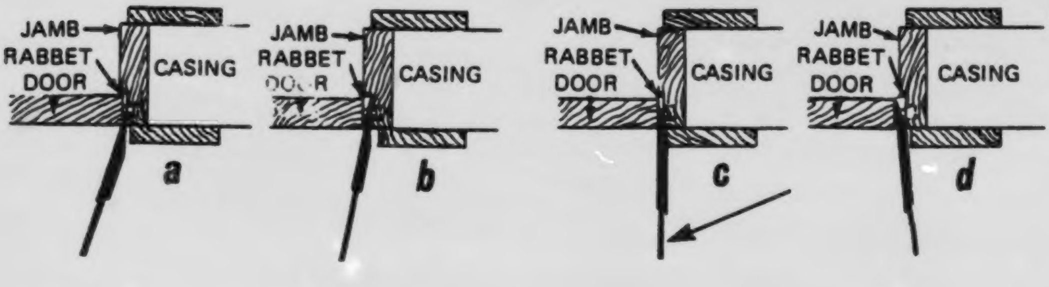

Figure 3-27. Forcing a door that opens toward you.

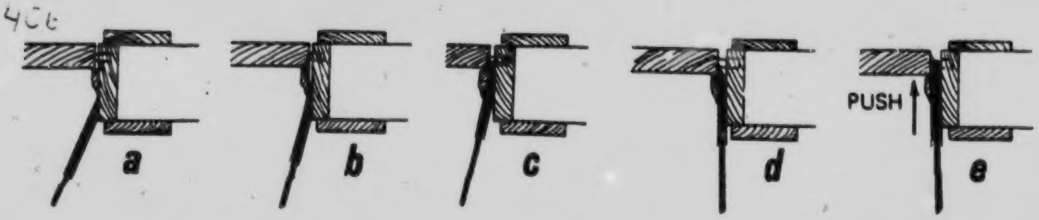

Figure 3-28. Forcing a door that opens away from you (stopped frame).

The steps in forcing a door that opens away from an operator when stops are used on the jamb are as follows and as shown in figure 3-28.

Step 1. Bump the cutting edge of the tool against the stop to break the paint or varnish so that the blade can be inserted, example a.

Step 2. Loosen the stop at the lock or remove the stop completely, example b.

Step 3. Start the blade between the door and jamb, example c.

Step 4. Make the initial pry only after the blade is halfway in to permit the blade to be worked and pushed, example d.

Step 5. With a full bite behind the door, pry the door away from the jamb until the bolt passes the keeper, example e.

Rabbeted Frame. If the door opening away from the operator is in a rabbeted jamb, it can more easily be forced by using two tools. Prying against the door with one tool should open a crack between the door and the rabbet, into which the blade of the second tool can be inserted. After the blade of the second tool has been forced well into this opening between the door and jamb, the door may be pried sufficiently to permit the bolt to pass the keeper. Even with two tools, forcing this type of door construction may be quite difficult. The steps in working the blade of a second tool into the crack between the door and rabbeted jamb are as follows and as illustrated in figure 3-29.

Step 1. Lay the blade of the tool flat against the door and insert the blade between the rabbet and the door, example a.

Step 2. With short pries of one tool, work the blade of the second tool between the door and the jamb, example b.

Step 3. Work or hammer the blade well into the opening, example c.

Step 4. With a full bite behind the door, pry the jamb away from the door until the bolt passes the keeper, example d.

Exercises (663):

1. What is gained by lifting the door stop and then inserting a tool between the door and jamb?

2. Why do you "bump" the cutting edge of the tool against the stop before inserting the tool?

3. How far should the blade of the tool be inserted between the door and the jamb before the initial pry is made when opening a stopped door?

4. To easily force a door in a rabbeted frame that opens away from you, you should use how amny tools?

5. Why are two tools needed to force a door that opens away from you in a rabbeted frame?

6. Describe how to open a door in a rabbeted frame that opens away from you.

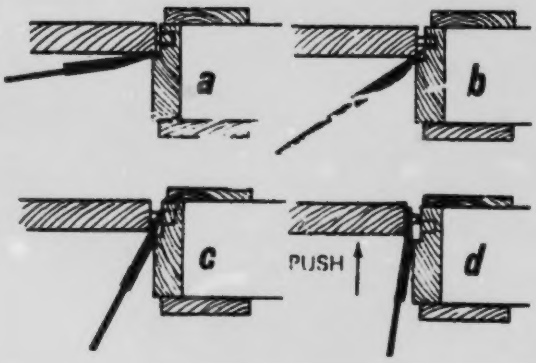

Figure 3-29. Forcing a door that opens away from you (rabbeted frame).

664. Specify how to force swinging doors and the difficulties of doing so.

Metal Swinging Doors and Door Jamb Construction. Metal swinging doors may be classified as hollow metal, metal-covered, and tubular. Metal swinging doors are generally difficult to force because of the manner in which the door and door jamb are constructed. This difficulty is more acute when the jamb is set in masonry. The framework of hollow metal doors is constructed entirely of metal. The jambs are hollow and are fastened to the walls by metal anchors.

Locks and Fasteners. Door locks and fasteners for swinging doors consist of a bolt or bar that protrudes from the door into a metal keeper which is mortised into the door jamb. This bolt or bar may be a part of the lock assembly, or it may be entirely separate; but, in either case, the jamb must be sprung enough to permit the bolt to pass the keeper during forcible entry. Some special installations place two bars on the door, one at the top of the door and one at the bottom; such door locks are exceedingly difficult to force. A record of the type of door and how it is locked can be valuable to firefighters if such information is collected during inspection surveys.

Techniques of Forcing. The method to use to force a swing door is determined, first, by how the door is hung, and second, by how it is locked. Before attempting to force any door, a firefighter should check to see whether or not the door is locked and whether or not the hinge pins can be removed. Before any door is opened or forced, the conditions of the building should be observed and hose lines should be made available for use. The firefighter should then feel the door for heat with the back of the hand because the back of the hand is more sensitive to heat than the palm. The temperature of the door will indicate whether a backdraft (explosion) is likely to occur when the door is forced or opened.

Double swinging doors may be forced by prying the two doors sufficiently apart at the lock to permit the lock bolt to pass the keeper. Sometimes a wood molding is fastened to an edge of one door to cover the crack between the doors. This molding must be removed before the blade of the tool can be inserted. Many times swinging doors are secured with a bar on the inside that is dropped into stirrups or hooked on the inside wall. Doors secured in this manner must be battered in if forcing is necessary. It may be possible, however, to cut a hole in one of the door panels or break a glass panel and remove the bar.

Exercises (664):

1. Why are metal swinging doors generally difficult to force?

2. What is the framework of hollow metal doors constructed of?

3. What type of door lock installation on swinging doors is exceedingly hard to force?

4. What is the second determining factor in forcing a swinging metal door?

5. Before forcing a swinging metal door, what must you do? How do you do it? Why do you do it that way?

6. How are double swinging doors forced open?

7. When would you have to batter a door in to open it?

665. Compare the difficulties of breaking tempered plate glass doors, other glass doors, and revolving doors.

Glass Doors. The breakage characteristics of tempered plate glass are quite different from those of ordinary plate glass. This difference is due to the heat treatment that is given to the glass during tempering. When broken, the sheet of glass suddenly disintegrates into relatively small pieces. Tests that have been conducted warrant the basic conclusion that firefighters should use every other available means of forcible entry before deciding to gain entrance through an opening that is blocked by a tempered plate glass door.

Whenever it may be necessary to break tempered plate glass panels, such breakage can be effected more easily by the pick point of a standard fire axe. A firefighter either should wear a suitable face shield to protect against eye injury or should turn their face and head away from the door as the glass is being broken.

The use of sharp-pointed instruments of hardened steel is more effective in breaking tempered plate glass panels. Blunt-faced instruments of unhardened or untempered metals have relatively little breaking effect when used in striking tempered glass.

Revolving Doors. Revolving doors consist of quadrants that revolve around a center shaft. The revolving wings turn within a metal or glass housing which is open to each side and through which pedestrians may travel as the door is turned. The mechanism of the revolving door is usually collapsible and panic proof, and each of the four revolving wings is held in position by hangers at the top and bottom. The wings fold from their revolving position to a wide open panic position when the hangers are collapsed. Some revolving doors will collapse automatically when forces are exerted in opposite directions on any two wings. All revolving doors do not collapse in the same manner, and it is a good policy to collect such information when fire department inspection surveys are made.

Exercises (665):

1. Why do tempered glass doors break differently than ordinary plate glass?

2. What is the easiest way to break a tempered glass panel?

3. What precautions should you take when breaking a tempered glass panel?

4. What breaking effect do unhardened or untempered blunt-faced tools have on tempered glass?

5. Describe how a revolving door operates.

6. How would you put a revolving door into a wide open panic position?

666. Specify the construction of given types of overhead doors and the difficulties of forcing them.

Overhead Doors. Doors that you open by moving them overhead may be classified as overhead, folding, rolling, and slab doors. Overhead folding doors are usually constructed of a wooden framework with plywood or glass panels, but there are a few made of fiberglass. The latch is usually in the center of the door; it controls the locks which are on each side of the door. The lock and latch may also be located on only one side. Figure 3-30 shows various ways in which overhead doors operate.

Overhead rolling doors. These doors are usually constructed from fabricated steel or aluminum, but some are made of wood. These doors may be mechanically, manually, or electrically operated. The barrel, on which the door is wound, is usually turned by a set of gears that are located near the top of the door on the inside of the building. This feature makes the door exceptionally difficult to open; therefore, entry should be gained at some other point and the door operated from the inside.

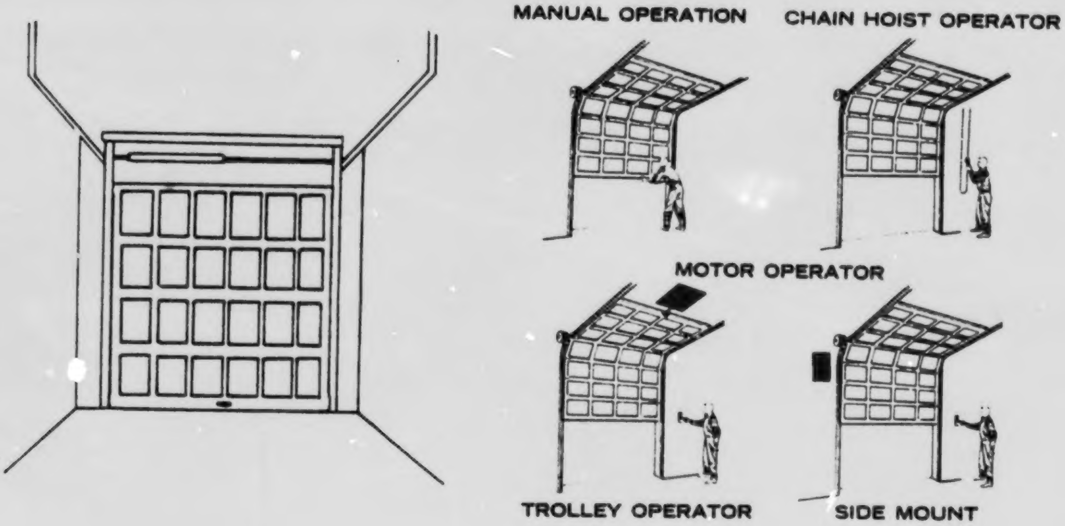

Figure 3-30. Overhead doors - operation.

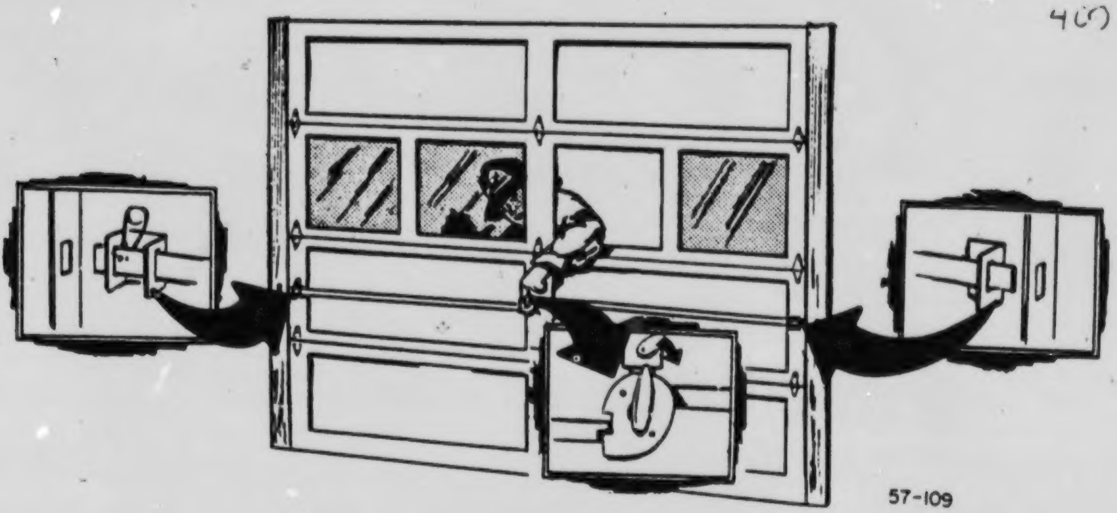

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Figure 3-31. Forcing an overhead folding door.

Overhead slab doors. These doors are constructed as one unit and open as such. They may or may not have a normal entry door made into them and may be either metal or wood; and, unless glass panels are present, it is practically impossible to reach the latch on the inside. Sometimes it is possible to pry outward with a bar at each side near the bottom. This action will tend to bend the lock bar enough to pass the keeper. CAUTION: All overhead doors should be blocked open to prevent injury.

Overhead folding doors. These doors are usually constructed of wood with or without glass panels. They are usually located in "housing areas" and are used as garage doors. Overhead folding doors are usually locked from the center of the door with the lock bar traveling to each side of the door. The lock bar actually travels through the door track and is usually difficult to force. To complicate the situation, many people drill a hole in the lock bar after it has passed through the door track and put a "padlock" here to further secure the door. The door may be forced by prying at both corners from the bottom of the door. Many times, the glass in the panel (if present) should be broken and the door unlocked from the inside. (See fig. 3-31.) This will lessen the damage to the door and is usually faster.

Exercises (666):

1. Where is the latch usually located on an overhead door?

2. The gears which turn the barrel, on which overhead rolling doors are wound, are normally located where?

3. What makes the overhead rolling doors so difficult to open?

4. How would you attempt to open an overhead slab door that did not have any glass panels?

5. What are overhead folding doors usually used as?

6. How do many homeowners (or renters) complicate the forcing of their garage doors?

7. Describe the easiest way to force a garage door that has glass panels.

667. Specify how to force windows and the precautions to take while doing so.

Windows. Prying with a wedge is the principle operation in forcing wooden framed windows; however, with the advent of crank adjusting windows, metal framed windows, new locking devices, and other innovations, it has become necessary to update our way of thinking. A wooden frame can be forced with a minimum amount of damage, but metal framing, once it is forced, usually is beyond repair, especially aluminum. The least amount of damage is

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caused by breaking the window, removing the glass pieces that could cause injury, reaching in, and opening the window. The fire axe, claw tool, spanner wrench, or any other wedge-shaped instrument can be used for forcible entry on windows. Factory or projected type windows consist of steel sashes, which are often set so solidly in the frame that only a portion of the window may be opened. The moveable portion is generally either pivoted at the center or hinged at the top and latched on the inside. Since factory or projected type windows have small panes, breaking a glass near the latch becomes a fast, simple operation which causes negligible damage. Jagged pieces of glass left on the sash should be cleared out before reaching in with the hand. Wired glass must be completely removed from the sash.

Breaking Glass. In some cases, less damage may be done by breaking a small glass through which a door or window can be opened from the inside. The act of breaking glass must be done in a certain manner to assure safety to the firefighting, because glass will shatter into fragments of keen cutting edges. Some of the principle safety features for breaking glass are: Stand to one side of the glass pane to be broken (with the wind to your back, if possible); strike the tool at the top of the pane; and keep the hands above the point of impact. This procedure permits the broken particles of glass to fall downward away from the hands and to the side of where the firefighter stands. Turn your face away from the glass just before the breaking object strikes the glass if you are not wearing safety goggles. The glass may be broken with an axe, spanner wrench, or other tools. CAUTION: Never break glass with the hands.

Full protection clothing should always be worn when breaking glass. After the glass is broken, all jagged pieces should be removed from the frame. Glass removal may be done with the same tool that was used to break the glass. Removing all pieces of glass will prevent the cutting of anyone who goes through or reaches through the opening and will prevent injury to hose, ropes, or other material that may be passed through the opening.

Exercises (667):

1. What is the principal operation in forcing a wooden framed window?

2. What effect does forcing have on an aluminum window frame?

3. How would you force a metal frame window so as to cause the least amount of damage?

4. Why must glass be broken in a certain manner?

5. Describe how you would position yourself when breaking the glass in a ground floor window on the east side of a house facing north with the wind coming from the south.

6. What should NEVER be used to break glass?

668. Specify how to force a casement window.

Casement Window Construction and Forcing Techniques. Casement windows are usually made of metal, but wood casement windows are used. They consist of one or two sashes which are hinged on the side and swing outward from the opening. If screens are employed, they are located on the inside opposite the direction in which the windows swing. Some of these windows are operated by cranks; others have a notched push bar. The notched push bar keeps the window in position when it is open and acts as a latch when it is closed. It must also be pointed out that casement windows are latched but that the operating mechanism must be reached to open the window. To reach the latch involves cutting the screen. It is quite obvious that the screen must be removed if entrance is to be made at this point. Because of these conditions, the most practical way to force entrance through casement windows is as follows:

1. Break the lowest pane of glass and clean out sharp edges.
2. Force or cut the screen in the same area.
3. Reach in and upward to unlock the latch and then operate the cranks and levers at the bottom.

Exercises (668):

1. What is a casement window?

2. How do casement windows operate?

3. What must be done before entry can be made through a forced casement window?

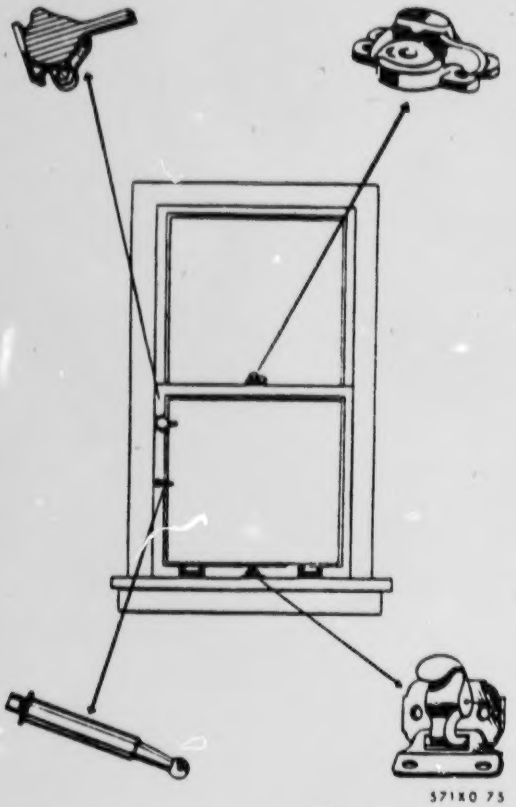

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Figure 3-32. Checkrail window and locking devices.

4. How should you force a casement window?

669. Specify how to force a checkrail window.

Checkrail Window Construction and Forcing Techniques. Checkrail windows may be made of either wood or metal, but the construction design is quite similar. They usually consist of two sashes that slide up and down in tracks formed in or by the window frame itself and meet in the corner of the window. They are known as the upper and lower sashes. These two sashes may be locked together by a latch or bolt on the inside. Both wood and metal checkrail window construction and their locking devices are shown in figure 3-32. The technique of forcing them is shown in figure 3-33. Wood checkrail windows are not difficult to pry open if the latch is on the checkrail, for the screws of the lock will pull out and the sashes will separate. Practically any prying tool, such as an axe or spanner wrench, can be used. The pry should be made at the center of the lower sash if the sashes are locked at the checkrail. If the window is locked with fasteners in the window casings, two pry tools should be used, one on each side of the window.

Exercises (669):

1. What is a checkrail window?

2. Why are wooden checkrail windows with the latch on the checkrail so easy to open?

3. How do you open a wooden checkrail window that has the latch on the checkrail?

4. How many tools should be used if the window is locked with side mounted fasteners?

670. Specify how to force projected windows.

Projected Window Construction and Forcing Techniques. Projected (or factory) windows are ordinarily made of metal, and they may project in or out from an opening. They may be pivoted in the center, or they may pivot at the top or bottom. "Projected Out" factory windows swing outward at the bottom and slide down from the top in a groove which is provided for that purpose. "Projected In" factory windows swing inward at the top, and they are usually HINGED at the bottom. The type of lock usually reveals the direction the window is to be projected. Pivoted projected windows are usually operated by a push bar that is notched to hold the window in place. Screens are seldom used with this type of window; when they

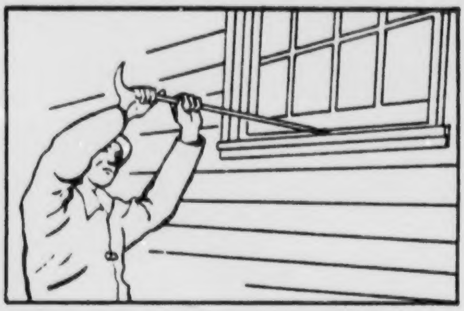

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Figure 3-33. Opening a checkrail window.

are, they are on the side opposite the direction of projection. The most practical method of forcing factory-type windows is the same as has been previously described for casement windows, except that the crank-operated mechanism is not often employed. Basement and utility windows are often of the projected type, and they are locked similarly to all other projected windows. Entrance may be made by applying similar techniques.

Exercises (670):

1. Where may projected windows be pivoted?

2. What information may usually be gained from the type of lock on a projected window?

3. How would you force a projected window?

671. State the difficulties of forcing awning and jalousie type windows.

Awning or Jalousie Window Construction and Forcing Techniques. Although awning and jalousie windows are often considered to be of the same type, there are two main differences that should be considered in a study of forcible entry. Both types are sometimes referred to as louver windows because of their methods of operation. The two main differences between these types of windows are described in the following paragraphs.

Awning windows consist of large sections of glass about 1 foot wide and as long as the window width. Jalousie windows consist of small sections about 4 inches wide and as long as the window width.

Awning window sections are constructed with a metal or wood frame around the glass panels, which are usually double-strength glass. Jalousie window sections are usually without frames, and the glass is heavy plate that has been ground to overlap when closed.

The glass sections of both awning and jalousie windows are supported on each end by a metal operating mechanism. This mechanical device may be exposed or concealed along the sides of the window, and each glass panel opens the same distance outward when the crank is turned. The operating crank and gear housing are located at the bottom of the window. Awning or jalousie windows are the most difficult of all types to force. Even with the louvers open, it is obvious that there is not enough room between the louvers to permit a person to enter. Entrance between these windows requires several panels to be broken out or removed. Because of the cost of jalousie windows, these openings should be avoided.

Exercises (671):

1. Why are both awning and jalousie type windows sometimes referred to as louver windows?

2. What is the difference between the glass in the awning and jalousie type windows?

3. Why are the awning and jalousie type windows the most difficult to force?

672. Specify how to force screened or barred windows.

Screened windows. Heavy wire mesh guards over windows and doors present a serious problem to forcible entry, ventilation, and firefighting practices. These mesh guards may be permanently installed, hinged at the top or side, or fitted into brackets and locked securely. In either case, forcing wire mesh guards involves considerable time and should be avoided. If you must go through one of these windows, the bolt or cable cutters may be used to cut the mesh, or the frame work may be forced open. Don't forget that you also have a power saw that may be used if needed.

Barred Windows. To free bars in masonry, a firefighter should strike the bar with a sledge hammer about 10 inches from the sill. As the bar bends in, the end will sometimes pull free of the sill. Another method is to strike the sill with a sledge opposite the end of the bar. A blow at this point will sometimes crack masonry sufficiently to release the end of the bar. Still another method is to start a hammerhead pick in the masonry sill at the end of the bar. Strike the head of the pick with a sledge to crack the masonry sufficiently to release the end of the bar. A pry bar may be used. The bars may be cut with a rescue saw.

Miscellaneous Openings. Iron gratings may be found in sidewalks above basement windows, in floors, or in walls. They may be merely held in position by the friction of the grating against the sill; they may be pivoted at the rear; or they may be set in masonry and locked in position with hasp and padlock. They can sometimes be opened with the pick end of the axe by forcing it between the sill and the grating and then prying up.

Exercises (672):

1. Why would windows with wire mesh guards be avoided if at all possible?

2. When freeing window bars from a window, about how far from the window sill should the sledge hammer strike the bar?

3. If an iron grate is held in place by friction, how may it be opened?

673. Specify basic search practices for structures.

We, as firefighters, must know how to gain entry into a building under all conditions. We must also know how to gain entry while causing the least amount of damage, where to gain entry in order to get to the victims, and how to get them out. As you all know, there are many factors to consider before forcible entry is made, and we must weigh all factors, know when and how to perform our job, and do it right.

Rescue operations are often complicated by the fact that the casualties must be located under the most difficult and hazardous conditions and then must be removed to a place of safety before first aid can be administered. First consideration should be given to the victims trapped on the premises. If fire is present, attack on the fire is very important in facilitating rescue operations. The prevention of panic in hospitals, places of public assembly, and schools is very important. A serious, calm, and efficient manner on the part of the firefighter will play a large part in quieting the occupants. NOTHING WILL EXCITE THE PUBLIC MORE THAN A LOUD, EXCITED RESCUER. Rescuers should check with the members of the family, other employees, neighbors of the family and bystanders to determine if and where there is anyone remaining in the building. A thorough search of the building must be made even if all persons are accounted for. Occasionally, neighbors, friends, or trespassers will enter buildings without the knowl- of the occupants. A search must be made as rapidly and as safely as possible, so it should be systematic as well as thorough. The rescuers should work in pairs and be equipped with a breathing apparatus and lifeline.

There is no real dividing line between a basic search pattern and a primary search pattern. You must keep in constant touch with a wall in order to make any search. You will more than likely not know any building you are called upon to search; therefore, maintaining wall contact is of the utmost importance so that you will not get lost or search the same area twice.

Search procedures are very important and must be accomplished rapidly. You must know how to search a smoke filled building in order to find victims and remove them. If you don't know how to search, you can get lost while in the building. You must follow set procedures, know your patterns, know how to search alone, and know how to search with your crewmembers and with other crewmembers when they are available for rescue. You must have the layout of the building in the back of your mind always, know where to start your search, and know where to look. In base housing at 0100 hours, your search procedures would be different than they would be in a CBPO at the same time. By the same token, your search pattern would be about the same in the base nursery at 1400 as it would be at 2200. All factors must be taken into consideration.

The first arriving crew will conduct the initial or primary search; this should be started on the fire floor and should then move to the floor above the fire. In the case with no fire, the search should begin at the lowest level in the building. The rescuers who must search the floor above the fire have the most dangerous position of anyone at the fire. They are searching the area to which the fire is likely to extend. As in many other rescue situations, searching is a race against time; aimless searching may cost the lives of occupants and searchers alike. Therefore, a thorough, efficient method should be used. Two persons can check an average residence in a very short time by keeping on their hands and knees, following walls, and reaching out with the outside hands and feet as far as possible.

If heat and smoke prevent entrance to an area, probe with arms and legs or with a tool to determine if anyone is lying close to a door or window. Victims are often found near a means of egress, particularly near the main stairs or fire escapes, near windows or other secondary means of egress. Rescuers should ventilate as they move by windows and doors by opening them provided the fire will not be extended by such ventilation.

When searching, you must remain alert at all times. It is important that you remain on hands and knees at all times because of unknown openings—such as elevator shafts, stairwells, and opening in the floor—which may be found when and where least expected. With your hands in front of you, you can search ahead of you and maintain a safe state of balance. The feeling in your hands is more acute than that in your feet. You must also remain alert to the possibility of building collapse or fire that may cut off your escape.

If possible, the searcher should carefully check the beds and under the covers. Look under beds, behind furniture, and check all closets thoroughly. Children and elderly people often hide from fire in such places when they become frightened. An easy way to check under the bed is to insert your leg beneath the bed and sweep gently back and forth. When finished searching a bedroom, it is common practice to flip the mattress into a "U" position to indicate that the area has been searched. This method also prevents duplication of search. A search pattern starting at the left of the point of entry, and continuing from left to right around the area to be searched at arms-reach intervals to the center of the search area, is the best to follow. Using this pattern, you won't get lost or search the same area twice.

Safety, for the rescuer, is often as close as a well hung, solid door. When trapped by the advance of fire, find such a door and get behind it. When rescue personnel are trapped, they should throw a helmet outside on the ground; this indicates to other firefighters that someone is trapped on the inside of a building.

Exercises (673):

1. When rescue is performed on a structure, first consideration should be given to which victims?
2. With whom should you check to determine if anyone remains in the building under consideration?
3. Why is a thorough search of a building necessary when all known occupants are accounted for?
4. When searching a building, how many should work together? What equipment should you have?
5. Why should you maintain wall contact when making a search?
7. Where should the search begin?
8. When making a search of a structure, in what position should you be? What route should you follow? How should you use your hands and feet to make the search?
9. Where do children and elderly persons often hide from a fire?
10. How would you indicate to other searchers that you have searched a bedroom?
11. How can you let fellow firefighters know that you are trapped inside a building?

674. Specify how to make a secondary search for victims.

The Secondary Search. Frequently, the individuals assigned to the initial search must work under extremely difficult conditions. Punishment from heat, smoke, and physical strain, combined with poor visibility, sometimes results in victims being missed during the primary search. Therefore, as soon as conditions permit, a person or team must be assigned to make a secondary search. Remember, on the secondary search, thoroughness, not time, is the most important factor. Nothing should be taken for granted, every possible hiding place must be searched. Rescuers should be impressed with the great importance of making a thorough search, even in buildings which appear vacant. Very often children and derelicts wander into vacant buildings and are trapped by fire.

Locating Victims. After making a preliminary size-up of the situation, a fire officer should immediately direct operations toward rescuing those victims who can be seen and heard. The exact location of concealed victims is not likely to be known at this time, but rescue operations must be initiated for these victims when their locations are made known. The process of locating victims is not an easy task, nor is it one which can be hurriedly undertaken. In spite of one's anticipation of finding someone in need, the entire process should be conducted in an orderly manner. Indiscriminate and careless moving about by rescue personnel should never be tolerated. This requirement makes it all the more necessary for fire officers to exercise their authority, since volunteer workers are often used to assist in locating victims. It is essential that these workers be correctly led and required to function according to an established system. There is always a possibility that victims may be underneath rubble, and an unorganized, nonsystematic movement of material and debris may cause injury or death.

Below we discuss a practical system which has been tried and proven on numerous occasions. This system is not complicated, and the procedure can be explained to volunteer workers at the scene. The fire officer should demand strict adherence to the following easily understood system.

Outside search. Rescue workers should be arranged around the perimeter of the area, and work should progress from the outer edge toward the center. At selected points, rescue workers should call out and then maintain a period of complete silence to listen for sounds from victims. Calls should be made from several points, and everyone must listen to determine a "fix" on any sound that is heard. If a "fix" attempt appears to be somewhat uncertain, an additional "fix" may be attempted from another angle. This procedure will minimize a possible mistake of going to the wrong place. Time which may be used to "sound" for victims and to pinpoint their location may save hours of unnecessary debris removal and possibly a human life.

Inside search. Rescuers should learn to use the art of listening and signaling although actual conditions are not always practical nor possible for training purposes. They should expect to hear moans, cries, or sobbing. Such sounds may go unheeded unless rescuers calmly listen for them. Firefighters may profitably practice identifying expected sounds by setting up simulated conditions where they can follow them through obstructed and darkened areas. If a victim is conscious, he may be calling and able to answer calls. Unnecessary yelling by rescuers will only excite a victim, but a well-modulated call or answer to a call will set a victim at ease. Calling through or tapping on pipes or other objects will produce a sound that will usually carry over the length of the object. A systematic tapping or calling, repeated at intervals, will not only let a victim know that someone is looking for him, it may also permit him to answer the signal.

Rescuers must also anticipate actions of victims who are under stress and impending danger. Rescue workers must perform their task with understanding, and they must think their way through every situation. Locating victims in buildings that are still standing but badly damaged presents a serious but less complex problem. A definite plan should be followed to insure that no part of the building remains unsearched. The search should be conducted by rescue workers working in pairs. The initial size-up, the initial decision, and the development of supplemental decisions will determine the method and techniques that will be used. The method chosen, the techniques used, and the time required to reach a trapped victim will differ, depending upon the type of incident and situation involved. This type of search should be made by trained firefighter rescue teams. The use of volunteer workers for inside search and rescue should be avoided.

When you enter a smoke filled room/building to search for victims, your search cannot be haphazard. You must have a plan for searching, know where to start, and know what to listen for. If you don't have a plan and do not know where you are going, you can get lost; then, instead of being a rescuer, you become a rescuee. Remember, there is a difference between the primary and secondary search. In the primary search, you are going for speed in locating the victims; in the secondary search, you must be thorough above all. These procedures, like all Fire Service training, are no good on an occasional basis; they must be standard operating procedure.

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Exercises (674):

1. When should a secondary search be conducted?

2. What is the most important factor when making the secondary search?

3. What may be the result of an unorganized, nonsystematic movement of materials and debris during a search?

4. How do you "sound" for a victim?

5. What effect might unnecessary yelling on the part of rescuers have on victims?

6. What will determine the method and technique used to search inside a building?

7. The use of volunteer workers for search and rescue should be avoided under what conditions?

3-6. Aircraft Rescue

There are many, many types of aircraft in the Air Force. That means to us, as firefighters, that there are numerous crew positions. We must know these areas on all types of aircraft that may have crewmembers in them. But we must not stop there. Some normal crew positions are not used in emergency landings. We must, therefore, know the emergency crew positions also. Knowledge of these crew positions will help us to determine our entry point for rescue. There is no reason to go to the wing root of an aircraft and cut your way in if all crewmembers are forward and an entry door is nearby.

675. Specify where to search for aircrew members in an aircraft.

Normal Crew Positions. You, as a firefighter, must be familiar with crew and passenger locations for the type of aircraft involved. The location of passengers and crewmembers will vary according to type of aircraft and different configurations. Depending upon

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the aircraft, doors may be located on either side of the fuselage. They may open to the inside, up or down. In many cases, an emergency release is provided in the interior at the hinge side of the door. If conditions permit, enter the aircraft through the normal entrance since this provides the most effective and expeditious means into the aircraft for rescuing personnel.

The normal crew position is defined as the location of the aircraft crew during air and ground operations under normal conditions. Generally speaking, the normal crew position is on the flight deck. There are some aircraft which carry a relief crew onboard. Even though these would be considered the normal crew, they would not be located on the flight deck. Usually there is an adjacent room to accommodate this relief crew. The normal crew positions may be located in ejection seats if the aircraft is equipped with them. On fighter aircraft, the normal crew position is always in the cockpit; on large cargo/passenger type aircraft, the normal crew positions may be a combination of places.

At the site of a severe crash when the aircraft is torn apart, the first place to check for victims is the normal crew position; however, we must not take for granted that all victims have been located until the entire wreckage has been searched. The victims may have been thrown from the normal crew positions or may not have been secured to the correct places when the crash occurred; thus, they will not be in the normal crew positions. On an emergency landing, the crewmembers may try to escape before the aircraft comes to rest and may be thrown outside the aircraft, may be trapped by cargo, or may have escaped unaided.

Emergency Crew Position. The emergency crew position is defined as any position other than the normal crew position to which a crewmember is required to go for an emergency landing, crash landing, ditching, or other dire emergency. In some Air Force aircraft, a crewmember is required to change from the normal crew position to a place of greater safety for an emergency condition. This is not required on a great majority of aircraft; but on aircraft with boom operators and tail gunners, these personnel are required to come forward to make rescue easier.

In any case, it is essential that you, the rescuer, make a thorough search of the wreckage. This will be no easy job. The situation may be a smoke-filled or gas-filled aircraft or a major aircraft crash. Much is to be considered during preincident planning—what type aircraft is involved, passengers, cargo, crew positions, time available to effect rescue, etc.

Exercises (675):

1. What determines the location of crewmembers and passengers on aircraft?

2. What does the term "normal crew position" mean?

3. Where are normal crew positions located on fighter type aircraft?

4. Where is the first place you check for victims on a severe crash?

5. What are emergency crew positions?

6. What type of aircraft require crewmembers to change location for emergency crew positions?

676. State the position of normal doors and hatchets and how to enter them.

Normal Doors and Hatches. Normal crew entrance/exit doors and hatches have a variety of arrangements, depending upon the aircraft involved. They may be located on either side, bottom, or top of the aircraft. Generally speaking, if a plane crashes on your installation and you have no information on this aircraft, you should approach on the pilot's left since this is the rescue side on most aircraft.

As a firefighter, you must realize that time is your worst enemy. You must continually search for ways to improve your rescue operations. One way to save time is to use the normal entrance doors for initial entry whenever possible. These are usually readily available and familiar to both you and the aircraft crew. On large cargo/transport aircraft, there may be several normal entrance doors. Some of these have emergency hatch releases that disconnect the hinges and allow the door to fall free of the aircraft. The only way to become proficient in the operation of these doors is to practice.

On fighter type aircraft, through the canopy is the only means of gaining access to the crewmembers. Vague instructions in opening procedures are usually printed on the outside of the aircraft. When performing rescue, you must decide for yourself what the situation warrants, i.e.; jettison the canopy or gain entry manually. The normal means to gain access to the cockpit of a fighter can be electrically, hydraulically, or pneumatically. On some aircraft, the canopy must be unlocked manually and then raised normally (automatically). Before any canopy can be opened manually, it must be unlocked.

There are numerous types of normal entrance doors, from the bottom hatch on the B-52 to the canopy of the T-37. Ingress and egress systems differ from one type of aircraft to another, and we cannot cover them all here. You must be proficient in aircrew extraction from all aircraft on your installation and from those that are frequently transit. Remember that you aren't producing electricity, paving streets, keeping records, or building houses. If you make a mistake when you work, someone is likely to lose his life. The only way to prevent this is by training.

Exercises (676):

1. Normal crew doors and hatches are located at what point on the aircraft?
2. If an unknown type of aircraft crashes at your base, from what direction should you approach the aircraft?
3. As a firefighter, what is your worst enemy in rescue operations?
4. How do you become proficient in the operation of doors and hatches on aircraft?
5. On fighter type aircraft, how is access to the crewmember(s) gained?
6. What are the normal means of gaining access to crewmember(s) of fighter type aircraft?

677. Specify how to enter aircraft through emergency doors, hatches, and windows.

Emergency Doors, Hatches, and Windows. Large frame aircraft with the wings on the bottom of the fuselage, such as the KC/C-135 and 747, have emergency entry-exit hatches over the wings. This is to facilitate quick escape by passengers. These hatches usually open to the inside and fall free of the aircraft. Most of these hatches are clearly marked on the inside and outside. Depending on the aircraft, several of these emergency escape hatches may be located along the length of the fuselage, but the ones over the wings should be used whenever possible. If the aircraft is on belly, the passengers can walk down the trailing edge of the wing to the ground with ease. If hatches are located at other locations, they will usually be equipped with slides. These are also valuable in rescue operations. Some slides must be thrown out the hatch and held in position; the later model aircraft have the self-inflating type.

On most military fighter type aircraft, the emergency entry is through the canopy by jettison or cut-in. Jettison should be attempted only when the normal and manual means have failed. Cut in to the cockpit as a last resort. When this canopy is jettisoned, it is expected to fall to the aft of the aircraft, but this does not always hold true, especially when the aircraft is at an odd angle or in a strong wind.

The jettison mechanism is usually a lanyard of varying lengths. Before jettisoning, make it known to other personnel in the area. Jettison may be activated on aircraft regardless of the position of the ejection handles on the ejection seat (except on the F-106). If the handles are in the raised position on the F-106, DO NOT JETTISON THE CANOPY or the seat will be ejected. On some aircraft, the canopy cannot be jettisoned if it is partially or fully open.

Large frame aircraft with the wings on top of the fuselage, such as the C-5, usually have emergency escape hatches on top of the fuselage as well as on the sides. These are usually equipped with escape ropes, since the distance to the surface may be several feet. On a wheels-up landing, the normal entry doors may not be useable because of the curvature of the fuselage.

On most aircraft, the cockpit windows on the pilot and copilot sides are escape routes and can only be opened from the inside. All other emergency escape hatches may be opened from the outside.

Exercises (677):

1. Large frame aircraft with the wings on the bottom of the fuselage will have emergency hatches located where?
2. If emergency hatches on aircraft of the type described in exercise 1 must be used, which hatches should be used first?
3. How is emergency entry made on fighter type aircraft?
4. When should jettison be used?
5. What is used as a last resort to gain entry to an aircraft?

6. What type of aircraft usually have escape hatches on top of the fuselage as well as the sides?

7. Which aircraft windows can only be opened from the inside?

678. Specify how to cut into aircraft.

If all other methods of gaining access have failed, an attempt must be made to cut through the wall of the fuselage. Some civilian aircraft and all military aircraft have areas of the fuselage designated for cutting. These areas are outlined with yellow or black dash lines and are labeled CUT HERE FOR EMERGENCY RESCUE or some other similar directive. When making a rectangular opening to permit access, only three sides should be fully cut. The fourth side may be used as a hinge and the skin bent out to form the opening. If the opening is on the upper part of the fuselage, the top side should be used as the hinge and the cut section swung outward and upward so that it will not obstruct movement from the interior to the ground. If the opening is low on the fuselage, the the bottom side of the cut section should be used as a hinge, swinging it outward and downward. Any cut section should always be opened outward rather than inward so as not to create an obstacle to the exit. Felt pads, carried by rescue companies, are for the purpose of padding sharp openings. Remember to use extreme caution when cutting on an aircraft. Make sure that the victims are not in danger.

In gaining entrance through a canopy by forcible means, the desire is to obtain the largest opening in the shortest period of time. Using the K-12 power saw, or the Target "Quickie," this is done by cutting the acrylic plastic along the edges of the frame. After cutting three sides, the acrylic plastic may be lifted off, breaking the fourth side.

Gaining entry into aircraft through the fuselage presents the most difficult problem in making a forcible entry. The increase in performance of aircraft has placed a demand on increasing the thickness and strength of the skin of the aircraft. When making cuts through the fuselage, you must have a knowledge of the interior. You must know the location of bulkheads, equipment inside the aircraft that would prevent entry, location of fuel tanks, fuel and oxygen lines, and otherwise where forcible entry presents the fewest obstacles to cut and gain entry. On large military aircraft, an outline of cutting areas is stenciled on the aircraft to aid fire protection/rescue personnel in making forcible entry. The aircraft that has these cut-in areas outlined will present the least problem in gaining entry. Rescue personnel must not depend upon these markings as they may be obliterated during an incident. However, during aircraft familiarization, fire protection personnel must carefully preplan these areas and become familiar with their location on all types of aircraft. When making forcible entry, always, if possible, gain the largest opening as quickly as possible.

Exercises (678):

1. How are cut-in areas identified on military aircraft?

2. How do you cut an opening in an aircraft on the upper part of the fuselage?

3. An opening cut in an aircraft should be opened in what direction for what reasons?

4. What are the felt pads carried on some rescue vehicles used for?

5. How should a canopy on a fighter type aircraft be cut with a power saw?

679. State why escape systems are installed on aircraft, the three types used in the Air Force, how they are actuated, and the person responsible for making any system safe.

Escape Systems. An escape system installed on an aircraft is designed to remove a crewmember from the aircraft in an emergency. Each type aircraft has a different escape system and requires a different safetying procedure. There are three types of escape systems utilized by the Air Force—the extraction system, the module, and the ejection seats.

These systems are not going to fire merely because the plane has crashed. They will not fire simply because you are in the cockpit. These systems are designed so that they will not "just fire" for no apparent reason. THE ONLY WAY AN ESCAPE SYSTEM CAN BE ACTUATED IS BY PULLING THE EJECTION HANDLE OR BY "COOKING OFF" due to fire in the cockpit getting into the seat catapult or rocket pack.

In the great majority of cases, the rescuer is either not well trained or has been taught erroneous information concerning escape systems. He is taught that the seat is extremely dangerous, so by the time he actually gets up on the aircraft to make rescue, he is so terror-stricken that he forgets what he is supposed to do. It is wise for you to be cautious, but you should not be afraid because the system will not actuate without cause.

It is your responsibility to assure that you can make any system safe. This is done only by proper training. When you are properly trained, you will be sure of the safetying procedures and will not be afraid to attempt it. You will know what to expect from that seat and when to expect it.

Exercises (679):

1. Why are escape systems installed in aircraft?

2. What are the three types of escape systems used on Air Force aircraft?

3. How are escape systems actuated?

4. Who has the responsibility of assuring that you can make any escape system safe?

680. State the basic operation of an aircraft extraction system and compare its danger to personnel to that of a conventional ejection system.

Extraction Systems. The extraction system described here is the "Yankee extraction system." It is a method employed to extract a crewmember from an aircraft by "pulling" instead of pushing him out. This system is presently being installed on slow-moving aircraft (such as the A-1 and T-28) that did not previously have an escape system. This system can also be installed on helicopters and can be used in other emergency situations.

This system is very simple in operation. When the ejection handle is pulled, the canopy is ejected (or broken) and the rocket (which can be in the upright position or in the horizontal position) is ballistically fired from the aircraft. When the rocket reaches a certain height, it pulls on the lanyard, which is attached to the rocket from the aircraft, and fires the rocket. The rocket is, in turn, attached to the occupant with nylon ropes. The occupant is consequently pulled from the aircraft by the rocket. The nylon ropes are long enough that the fire from the rocket does not endanger the occupant. This system is much safer than the conventional ejection seat. If you are attempting rescue when this system is actuated, your chances of survival are good because the occupants actually stand as they are pulled from the aircraft and the seat is left in the aircraft. Also, you don't have to worry about the fire from the rocket as you would in the conventional seat. It must be stressed, however, that if the seat is fired, the rocket leaves the aircraft with enough force to cause great danger to you if you are hit by it. Also, the canopy may shatter and throw glass in all directions.

Exercises (680):

1. How is an individual removed from an aircraft equipped with an extraction system when that system is actuated?

2. How is the extraction rocket fired?

3. Why are your chances of survival better in case of system actuation during rescue with the extraction system than with a conventional ejection system?

681. Compare the module ejection system and ejection seats.

Module Ejection System. The only module presently used in the Air Force is on the F-111. From the rescue point, the approach to this aircraft is more dangerous than any other aircraft. Once the aircraft is reached and entry is gained, the system is one of the easiest to safety. When the system is actuated, the entire cockpit is removed (ballistically) from the aircraft. This ballistic charge completely surrounds the module; and, when it is actuated, it sends scrap metal in all directions with enough force to kill the approaching firefighter. This module also has a zero-zero capability, which increases the possibility that the crewmembers may decide to eject instead of waiting to be rescued.

When an escape system has a zero-zero capability, this means that the system may be actuated at zero-speed and zero-altitude with a good chance of safe escape from the aircraft.

Ejection Seats. Ejection seats are the most common types of escape system. They are installed on small, medium, and large frame aircraft. In each aircraft equipped with an ejection seat, the seat is different from other aircraft. Sometimes the seats within one aircraft may differ, as in the B-52, where there are upward and downward ejection seats. Ejection seats fall into two categories, the catapult and the rocket-pack types.

Catapult type. The catapult is a telescoping device with the inner tube containing an explosive charge. This catapult is installed on the back of the seat. When the explosive is fired, pressure builds up on the inside, causing the catapult to "telescope," thus "throwing" the seat from the aircraft.

Rocket-pack type. The other type of seat is equipped with a rocket pack in addition to the seat catapult. The initial stage of ejection is the same as the catapult type; but, when the seat is catapulted so many feet from the aircraft, it pulls a lanyard which is attached to the rocket-pack initiator and the aircraft. This pull fires the rocket pack. This usually gives the seat a zero-zero capability. The rocket pack is installed on many of the former catapult type seats as a modification and on the more recent aircraft. If you are attempting to make rescue when this type of seat is fired and are not contacted by the seat when it leaves the aircraft, you are still in extreme danger of being "cooked" or "roasted" when the rocket pack fires.

Exercises (681):

1. The module ejection system is used on what type of aircraft?

2. Why is the module ejection system more dangerous than other systems?

3. How fast must an aircraft with a zero-zero capability escape system be moving in order for one to safely eject?

4. WHAT ARE TWO CATEGORIES OF EJECTION SEATS?

5. How is a seat removed from an aircraft having a catapult type system?

6. What is the function of the lanyard connected between the rocket-pack and the aircraft?

7. Besides being hit by the seat as it leaves the aircraft, what other danger is there to a firefighter during rescue should a rocket-pack-type system be actuated?

682. Specify the uses of aircrew restraint fittings.

Aircrew Restraint Fittings. Aircrew restraint harnesses and devices employ different types of connectors. The standard lap belt is used on most aircraft as a seat belt and often to attach the shoulder restraint straps to. (See fig. 3-34.) Most fittings are simple to

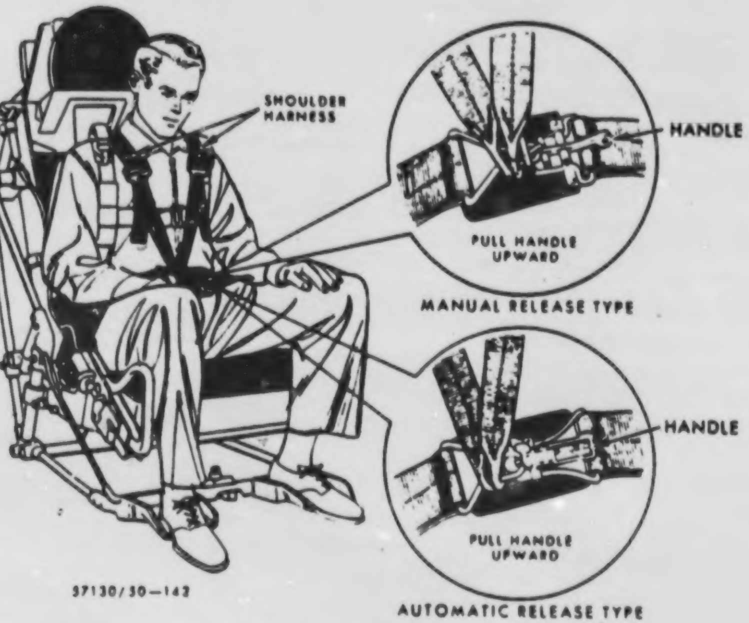


Figure 3-34. Seat belt and shoulder harness.

operate and can be operated very quickly; however, the Koch-fitting is quite difficult to operate and its operation is time consuming if the operator is not familiar with it.

Basically, there are two types of harnesses used by aircrews. The standard parachute harness is used to connect the crewmember to the parachute and seat when the parachute is not a component part of the seat. The crewmember can either wear the harness into the aircraft or the harness is attached to the seat itself. In either case, it is generally recommended that this harness be left on the crewmember during extraction so that he will have something to hold on to.

The standard military parachute harness can be removed by releasing three ejector fittings. One fitting snaps across each leg at the thigh, and the third fitting is across the chest.

To remove parachute: (1) unfasten the two leg straps by releasing the ejector fittings; (2) release the chest strap by releasing the ejector fitting; and (3) slip shoulder straps over the shoulders. The ejector fittings are released by pulling upon the release tabs.

The integrated torso harness is a harness worn by crewmembers when the parachute is a component part of the seat. These also have integrated restraints. The crewmember is removed from the aircraft wearing the harness in this case. The harness uses two types of fittings—the Koch and the Rocket Jet. To release the Rocket Jet fitting, you must squeeze the knurled buttons and slide the locking collar up, then lift the ring out. The Koch fitting is released by lifting the locking latch cover with the finger tips. Let the latch cover ride back over your fingers while you depress the actuating lever down and back.

Exercises (682):

1. What is the standard lap belt used as?

2. When is the standard parachute harness used?

3. Why is it generally recommended to leave the standard parachute harness on a crewmember?

4. What is the integrated torso harness?

5. What type(s) of fittings are used on the integrated torso harness?

683. Specify how to gain access into aircraft.

Gaining Access Into Aircraft. The easiest and quickest way for you to gain access to an aircraft is through normal doors and hatches. These normal openings usually have external releases. Forcible entry must be used if the doors or hatches are jammed.

Most of the new jet commercial aircraft are equipped with escape chutes or slides which may be inflatable and are generally released by a crewmember or passenger from inside the aircraft. If these chutes or slides are provided and in use when the rescue and firefighting vehicles arrive, they should not be disturbed unless they have been damaged by use or are threatened by fire exposure. The slides usually provide a much faster means of evacuation than steps or ladders. Aircraft windows may often be used for rescue or for ventilation. Some are designed to be used as emergency exits. On most aircraft, these exits are identified and have latch releases on both the outside and inside of the cabin. Most of these exits open toward the inside. Passengers using overwing exits for evacuation will normally slide off the rear edge of the wing or down the wing flaps. Assistance should be provided to prevent leg injuries. Individuals who have escaped may be able to tell the number and possible location of others still in the aircraft. It should never be assumed that all crewmembers and/or passengers have evacuated the aircraft. A thorough inspection must always be made.

Chutes or slides are not always provided on military cargo and transport aircraft. In some instances, a rope built-in ladder or steps, or a small portable ladder is carried within the aircraft for evacuation purposes. Steps are generally not built in fighter type aircraft, and the emergency crews responding must provide the means of gaining access to the canopy.

A jammed door may be forced open by using a pry bar, axe, or other wedge tool around the frame or at the hinges. If doors or hatches cannot be forced open, plastic or glass areas may be the fastest means of entry. Forcing doors or hatches should, however, be attempted first. When forcible entry is necessary for rescue, extreme care must be taken to prevent injury to the aircrew or passengers on the opposite side of the entry point. Glass or plexiglass panels are subject to shatter during forcible entry. The danger of injury is minimized by striking the panels at the corner farthest away from the victim. Speed is essential in most accidents from the victim. Speed is essential in most accidents requiring rescue, but speed must be tempered with common sense. A pick-headed axe could penetrate the covering and injure occupants of the aircraft. If an axe is used to shatter the pane, the flat side of the axe should be used first with comparatively light blows. The impact of the blows should be increased as needed. If the pane does not break or release under this action, the pick end of the axe should be used. It may be necessary to use a sledge hammer for extra thick panes.

Whenever a victim is to be removed through an opening which has been covered by a pane, the jagged edge must be removed or reduced as much as time will permit. This can be done rapidly if the pane were installed with a rubber seal. After the pane is shattered, the removal of the rubber seal will eliminate the jagged pieces.

Jettison is another method of opening a canopy. In fact, the canopy is thrown completely off the aircraft. This method is attempted when time is of the essence due to a fire or when normal and manual entry have failed.

The trajectory of the canopy is designed to be up and aft of the aircraft; but, because of the crash configuration for the aircraft, wind, and other factors, the canopy's trajectory may not be as planned.

Before pulling the external jettison handle (the handle located on the outside of the aircraft and identified as the jettison handle), assure that all personnel are out of the area to a reasonable distance and that the person pulling the handle is protected from the falling canopy. The individual can get under the wing, perhaps, to protect himself.

Engine Shutdown. The matter of engine shutdown, like most matters dealing with aircraft, must be dealt with in general terms. One of the main steps in the shutdown procedures for an aircraft is retarding the throttles. However, even this procedure differs greatly with different aircraft. For example, on some aircraft the throttles must be brought back and then outboard; on others, the throttles must be brought back and then up; and still others require that the throttles be brought back and then a lock tab released. The only way to know the correct procedure to use when the time comes is to familiarize yourself with each type of aircraft that you will normally be associated with at your particular location. In emergency shutdown, we are dealing with the same thing. Some emergency shutdowns can be accomplished by simply pulling a T-handle. Others require that a button be pushed in addition to pulling a T-handle. As you can see, it cannot be overstressed that YOU MUST KNOW YOUR AIRCRAFT! Also, you should consult TO 00-105E-9 for the exact procedures for normal and emergency engine and system shutdown and the location of the shutdown devices.

Exercises (683):

1. What is the easiest and quickest way to gain access to an aircraft?

2. Generally, by whom are the escape chutes and slides on commercial jet aircraft released?

3. Why should you assist persons that slide off the rear edge of a wing during rescue operations?

4. What information may you get from individuals who have escaped from a crashed aircraft?

5. How is a jammed door forced on a crashed aircraft?

6. When breaking the windows to enter an aircraft, how can you minimize the danger of injury to victims?

7. How should an axe be used to shatter a window pane on an aircraft?

8. When a canopy is jettisoned, what factors determine its trajectory?

9. What publication should you consult for normal or emergency shutdown of aircraft engines/systems?

684. Specify how to make escape systems safe.

Safetying Ejection Seats. The reason for safetying the seats is, of course, to prevent them from "firing." You may interrupt the firing sequence by cutting a hose or using quick disconnects, or you may prevent their actuation by pinning the ejection handles or initiators.

CAUTION: Regardless of how many hoses have been cut or how many pins have been installed, if fire reaches the rocket pack or the seat catapult, the rocket or the explosives will activate as if the ejection handle had been pulled.

Safetying systems using pins. The normal way to safety any escape system is to pin the ejection handles and, in some cases, the initiator. (See fig. 3-35.) In some instances, the only way you can safety the system is by using pins. The Esca-Pak is safetied by pulling the safety handles. The rescuer should only install enough pins to prevent the system from firing. You should not be concerned with pinning every initiator because there may be many. The major disadvantages when using pins is that the holes will be hard to find when there is foam, darkness, etc.

Safetying systems by interrupting the sequence. In the emergency situation, the rescuer may not be able to pin the system due to not having pins, or he may not know where the pins are to be installed. The other method (and usually the most preferred) of safetying a system is to interrupt the ejection sequence. This is done by disconnecting the "quick disconnects" (fig. 3-36) or by cutting the initiator hose before it reaches the seat catapult (fig. 3-37). This method is a "sure" way to safety the system, and the hoses are usually readily visible and vulnerable. If you do cut the initiator hose, be sure to bend the cut ends apart so that no gas will pass in case the initiator fires.

Extraction Systems. Safetying procedures for the Yankee extraction system are similar to the conventional seat. You must either prevent the extraction handle from being pulled (by pinning), or interrupt the firing sequence (by cutting the electrical initiation cable which resembles a coiled telephone cord or cutting the detonation cord).

NOTE: Page Number 424 has been omitted.
However, all course material is included.

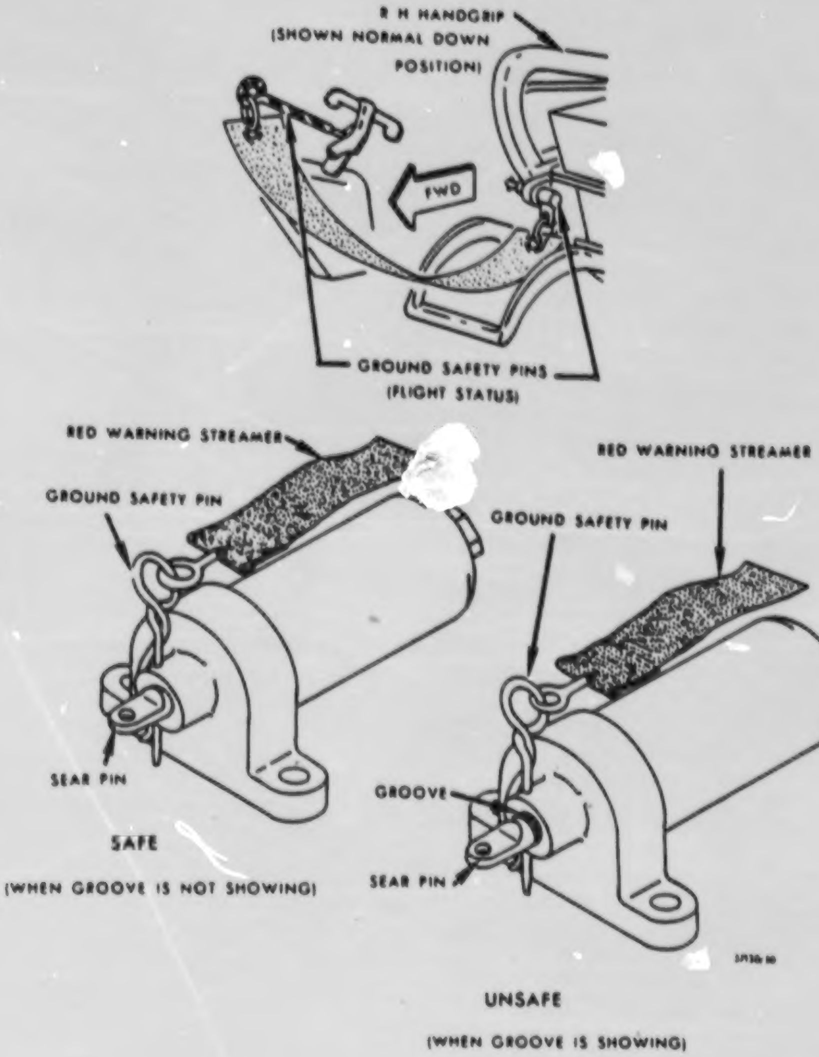

R H HANDGRIP
(SHOWN NORMAL DOWN
POSITION)
FWD
GROUND SAFETY PINS
(FLIGHT STATUS)
RED WARNING STREAMER
GROUND SAFETY PIN
SEAR PIN
SAFE
(WHEN GROOVE IS NOT SHOWING)
RED WARNING STREAMER
GROUND SAFETY PIN
GROOVE
SEAR PIN
UNSAFE
(WHEN GROOVE IS SHOWING)

Figure 3-35. Safety pinning.

Module Ejection System. The only method of safetying this system is to pin the ejection handles. This means you must gain entry to the aircraft and PIN BOTH HANDLES. There are no hoses or lines to cut and quick disconnects. Safetying can only be done by pinning.

Exercises (684):

1. What is the reason for safetying seats in an aircraft?
2. What is the normal way to safety an escape system?
3. What is the major disadvantage of using safety pins?
4. How do you make a system safe by interrupting the sequence?

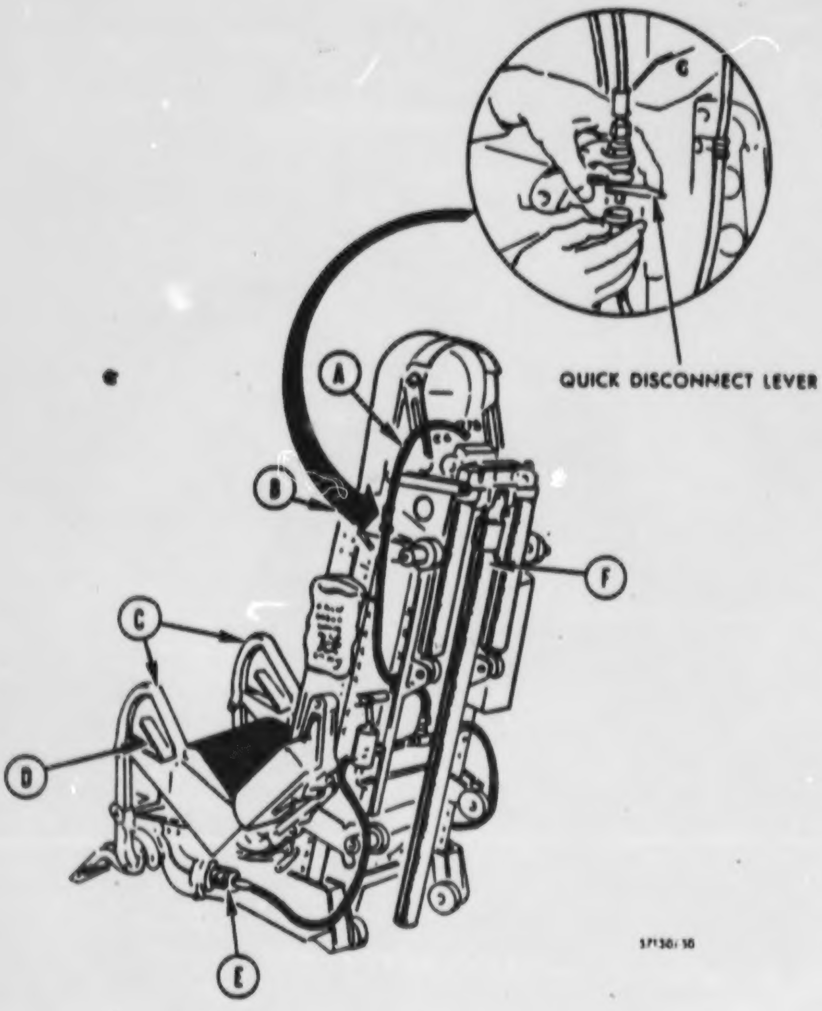
5. How is an extraction system made safe?

6. Which hoses or lines are cut when safetying the module ejection system?

685. Specify how to extract aircrew members.

Crew Extraction. As we covered the crew restraints, we did not cover the releasing methods. There are many aircraft, egress systems, and restraint methods, so this discussion of releasing crewmembers will be very general. It must be remembered that each one of us should be familiar with our base aircraft and transit aircraft. We must be aware of the location of all rescue aids and when and how to use them.

Rescue Aids. The job of rescue is one of the most difficult and dangerous in the world. You may be required to rescue a person from any situation imaginable and to do it without mistake or hesitation. You will usually attempt a rescue without hestiation, but



A. INITIATOR HOSE
B. QUICK DISCONNECT LEVER
C. HAND GRIPS
D. SEAT FIRING TRIGGER
E. EJECTION SEAT INITIATOR
F. EJECTION SEAT CATAPULT

Figure 3-36. Seat ejection system.

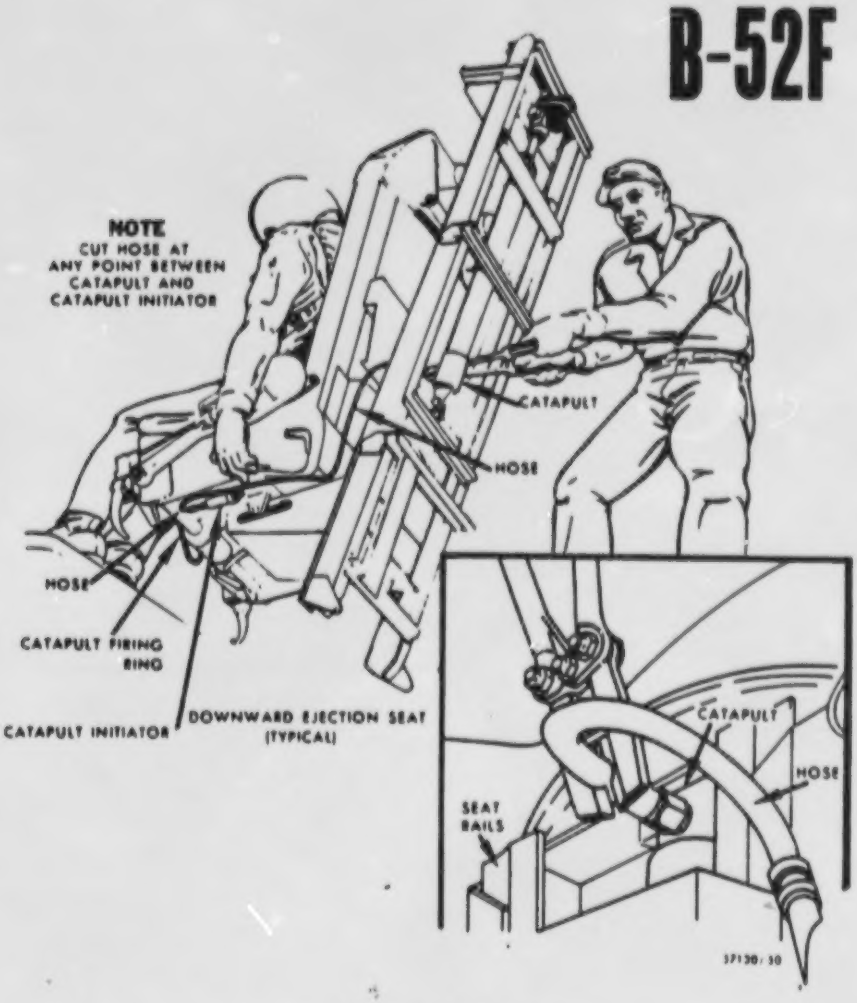

B-52F
NOTE
CUT HOSE AT ANY POINT BETWEEN CATAPULT AND CATAPULT INITIATOR
CATAPULT
HOSE
HOSE
CATAPULT FIRING RING
CATAPULT INITIATOR
DOWNWARD EJECTION SEAT (TYPICAL)
CATAPULT
HOSE
SEAT RAILS
37130/30

Figure 3-37. Cutting the initiator hose.

mistakes happen. The severity of the mistake depends upon the situation. To prevent these mistakes requires an enormous amount of training.

During the training portion of rescue, as well as during the actual rescue, you should use every aid possible to make your job easier and quicker. Aircraft rescue in particular requires speed and proficiency. Some of the aids that may be used in aircraft rescue are discussed below.

Seat controls. You can help yourself by positioning the seat to a more advantageous position. In cargo type aircraft, some of the seats will swivel 360°. The seats can be raised and lowered to help release the victim or put him in a better position for extraction.

Survival kit release handle. If the seat is equipped with a survival kit, as most ejection seats are, there will always be a survival kit release handle; this handle will ALWAYS BE ON THE CREWMEMBER'S RIGHT. It is on the kit itself and is solid yellow. It should always be pulled when making an extraction of the crewmember. When this handle is pulled (it must be completely removed from the kit), it releases the kit from the parachute harness. Pulling the survival kit release handle should be the first action because it is easily reached at this time. After the emergency harness release handle is pulled, you may not be able to reach the survival kit release handle.

Emergency harness release handle. This is another handle that should be used by the rescuer. This handle and the survival kit release handle should be all that is required to release before removing the crewmember. This handle releases the lap belt, leg and arm restraints, and shoulder restraint devices. This handle is a great aid to you and should be used whenever present.

Inertia reel controls. The inertia reel is a device attached to the shoulder restraint straps of the crewmember's seat. Its purpose is to restrain or retract the member in the spine-straightening position for instances of landings, take-offs, and times of ejection. This inertia reel is usually the first action in the ejection sequence of a seat but may also be locked manually.

If this reel is in the locked position, it may be necessary to release it before the crewmember can be released from the seat. There is a round black knob located on or about the left armrest of the seat which is used to lock or unlock the inertia reel. (On the F-111, this handle is located on the left and over the head of the crewmenber.)

The area of egress system safety is so wide that we can only talk in general here. We have covered the most common systems and how to safety them. But this is one area that takes continued training. If we must do the safetying, there is only one way to do it—RIGHT. To be sure you do it right, you should always check TO 00-105E-9 for the specific aircraft involved. And don't think for 1 minute that just because you checked the TO last year that all is well. The TO changes for TO 00-105E-9 come out hot and heavy, and you have to keep on the ball to stay up with them.

Exercises (685):

1. What good will it do you to know where the seat controls are located on an aircraft?

2. Where is the survival kit release handle located? What does it do?

3. What devices are released when the emergency harness release handle is pulled?

4. What is an inertia reel? What does it do?

686. Specify procedures for the removal of crewmember(s) from aircraft.

Approach. Under normal circumstances, three rescue team members should be used for operations at any situation. The activities, as outlined in the following paragraphs, are based principally upon the use of three persons at an incident. Rescuers should approach and enter the aircraft by way of the path cleared by the turrets and/or handlines. They should be extremely cautious when attempting to remove personnel from an aircraft which is surrounded by widespread fire because they, the rescue team members, are protected from the heat by protective clothing and may not feel the extreme temperatures to which they are exposing the victims. Keep in mind that flashbacks may cut off the means of escape.

Entry. Only two of the members of the rescue team should make the initial entry into an aircraft. The other member should stay at the opening until the members on the inside indicate that help is needed inside. The outside team member should be alert to conditions in order to warn the inside members if danger develops and to assist in the removal of victims through the opening. If the internal part of the aircraft is on fire, a person who is inside the plane must call for a handline to control these conditions during rescue.

A lifeline and breathing apparatus should be used any time the inside members are out of the sight of the rescue opening or of the outside team member. Aircraft are much like buildings so far as ventilation, protective clothing, and equipment is concerned. Some aircraft operations may require the use of lifelines.

Let's go through a typical fighter aircraft rescue procedure using #1 team member as the crew chief, #2 team member as the rescuer, and #3 team member as the driver.

Operations. Some of the following items may be done simultaneously. You should have two rescue team members at the same place, so one should be on one side of the aircraft crewmember and one on the opposite side of the crewmember (fighter-type aircraft only).

Step 1. The vehicle sets up on the aircraft (rescue side) and the crew chief goes to the canopy controls.

Step 2. The crew chief attempts to raise the canopy normally. If the normal operation fails, an attempt to raise the canopy manually must be made. If a manual operation is indicated, team member #1 will unlock the canopy, then go to the opposite side of the cockpit, being careful not to put themselves over the canopy. NOTE: The normal method of entry should be employed whenever possible because it is the easiest and fastest means to gain entry.

If you have an aircraft crash or other rescue situation requiring the rescue team to open the canopy, the normal method will be much faster and probably much safer than any other method. The explosives limit of jet fuels are such that an electrical spark is unlikely to start a fire if the canopy is electrical. And, in the crash situation, you will probably already have fire present or at least much more heat present (as a hot engine) than an electrical spark will produce. You must learn to put such items as electrical sparks in the proper context and realize that it is not such a great hazard after all. In the same breath, you must realize that the possibility of an electrical spark starting a fire is not entirely absent. The situation will determine to a large degree whether the normal method is to be used.

Step 3. Team member #2 comes to the rescue side of the aircraft with a pry axe, the initiator hose cutters, and the harness cutters.

Step 4. The two team members (1 and 2) raise the canopy manually (one on each side) and block the canopy in the full open position.

Step 5. The team member who is closest to the seat will immediately, and in conjunction with step 4 (if possible), safety the escape system, using one of the following methods:

(1) Install safety pins.
(2) Pull safety handle if incorporated.
(3) Open the quick disconnects.
(4) Cut the initiator hose.

NOTE: In this situation, let's say that the safety handle is not incorporated. Due to the foam, darkness, etc.; it is unlikely that you will find the holes for the safety pins. Look for quick disconnects and if there are any, disconnect them. If a quick disconnect is on each side of the seat, you must disconnect both of these. There is one team member on each side of the seat for the purpose of safetying the seat when the disconnect mechanisms are on each side are unknown. If there are no quick disconnects, cut the initiator hoses.

NOTE: There are a few aircraft which require safety pins to be safe.

Step 6. While team member #2 is shutting down the engines, member #1 can safety the oxygen system.

Step 7. Whichever person is closest will shut down the fuel switches and armament switch. These switches vary from aircraft to aircraft.

Step 8. Whichever person is closest will shut down the master or battery switches, and in that order if both are incorporated. Make sure fuel switches have been off at least 5 seconds before shutting off the master or battery switch. This is to allow the fuel valves to rotate closed.

Step 9. Team member #1 pulls the survival kit release handle and the emergency harness release handle, if incorporated, while member #2 positions over the victim to pull him from the seat. NOTE: If the aircraft doesn't have an emergency harness release handle, the victim will be released manually by the nearest person.

Step 10. Team member #2 gets a good grip on the victim's shoulder straps or under the victim's arms and JERKS the victim from the seat. Team member then sets the victim on the predetermined side and gives him to member #3.

Step 11. Team member #3 removes the victim to a safe area.

The above was a typical aircraft rescue sequence. It is not a concrete rule because each aircraft differs in some respects. Aircraft prefire planning should be established for each permanent and frequent transit aircraft on your base. These prefire plans will determine the procedures, and the practical training will determine your speed and accuracy.

Exercises (686):

1. Normally, how many rescue team members should be used for operations at any situation?

2. How should rescuers approach and enter an aircraft?

3. How many of the rescue team members should make the initial entry into an aircraft?

4. When should a lifeline and breathing apparatus be used during aircraft rescue?

5. Where does the rescue vehicle set up on an aircraft?

6. The first attempt to open a canopy should be made using what method?

7. What tools/equipment should the individual who is making the physical rescue take to the aircraft?

8. After the canopy has been raised to the fully open position, what should be done?

9. Which team member will safety the rescue system?

10. How will the escape system be made safe?

11. After shutting off the fuel switches, (a) how long should you wait to shut off (b) which other switches? And (c) in what order should they be shut off? And (d) why?

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12. How is the crewmember removed from his seat and set on the side of the aircraft?

13. What will determine the procedures used for aircrew removal? What will determine your speed and accuracy in removal?

3-7 Vehicle and Miscellaneous Rescue

Automobile accidents are the most common rescue situation that any rescue team is exposed to. Any number of situations can be associated with an automobile accident, including fire, explosion, trapped and pinned victims, and severe physical injuries. Extrication from automobiles requires many hours of training with tools, procedures, and emergency care.

Being in the rescue field may necessitate your presence at the scene of a natural disaster. During a natural disaster (and thereafter), the public will need all the help that is available to them. You will be working under far different conditions than you have ever worked under. You will also probably be working for a different boss.

As you can imagine, if you stay proficient in the art of rescue, you have a full time job.

687. Specify how to extricate victims from automobiles.

Extrication From Automobiles. Automobile rescue requires specialized training and special items of equipment. You should have a pry axe and K-12 saw, and you will find that you also MUST have some special items, such as port-a-powers and come-alongs. Very often, the victim of an automobile accident is killed by an attempted rescue instead of the accident. When you are dealing with people's lives, you cannot put a price on anything, because a tool or piece of equipment may prove priceless to the person being rescued.

Training is also a very important part of automobile rescue. Without training, you are likely to accomplish nothing other than seriously injuring or perhaps even killing the victim. You have a job to do that cannot be graded by the degree of accuracy with which you perform. You will be graded or judged by the success or failure of the mission (which is to rescue the victim). If the victim dies, even though through no fault of your own, there will be those who will blame you because you were there and available. If you successfully rescue the victim, you will be praised regardless of the mistakes that you know you made. In some cases, you may be officially charged with malpractice or misconduct, and rightly so if you do not do the job you are getting paid to do. Remember that people's lives are depending on you, and life is the most important asset a person has. In some cases, your own life may be at stake and may be lost if you make the wrong decision.

The general rule that no injured victim should be moved before he is given energency first aid can be disregarded if his life and well-being are endangered where he is. The victim should be moved out of danger at once, if possible.

Normally, extrication is divided into five stages, as follows:

- Gaining access to the victim.
- Conducting the primary survey.
- Disentanglement.
- Preparation for removal.
- Removal.

Gaining access to the victim. Gaining access to victims usually presents no problem. In the great majority of automobile accidents, the victim has either been thrown out in the crash, has removed himself, or has been removed by uninjured passengers or other motorists. The threat of fire is the main reason for hurried and possibly dangerous removal of victims from automobile wrecks. However, a recent survey of 42,000 accidents revealed that vehicles not on fire by the time the police arrived were not likely to catch fire.

Gaining access to the victim depends on the location and position of the automobile, damage to it, and the position of the victim in it. Access may be as simple as opening the door or as difficult as opening a car that is upside down at the bottom of a river or lake. Access might involve forcing open doors, cutting off the roof, breaking out glass, jacking up the car, or pulling a steering wheel or seat.

Lifesaving emergency care (primary survey). The primary survey is instituted, when necessary, while the patient is still in the car. This can be done during and after gaining access to the victim. The primary survey consists of (1) establishing and maintaining an airway; (2) giving artificial ventilation; and (3) controlling bleeding.

Cardiopulmonary resuscitation is not listed since it is ineffective when performed on a victim who is in a sitting position or in an automobile. The victim must be lying down on a flat, sturdy surface for cardiopulmonary resuscitation to be effective.

Disentanglement. The importance of disentanglement of the victim from anything restraining him inside the automobile must be emphasized, but your primary concern is still removal of the victim from the vehicle. Removing or disentangling the vehicle from the victim should be considered if it is the best way to prevent further injury. The victim may have been thrown up underneath the dash if he was not wearing a safety belt. He may have a part of the steering wheel impaled in his chest if he was not wearing the safety harness. Or he may be pinned in the automobile or partially outside the vehicle.

Preparation for removal. Once the automobile parts and other impediments have been disengaged from the victim and other physical restraints removed, the victim should be prepared for initial movement and subsequent transportation to the ambulance. Such preparation should protect the victim from further injury and facilitate removal. Fractures should be immobilized where possible, wounds dressed, and the victim "packaged" for lifting and removal.

Removing from automobile. Removal from the car and transportation to the ambulance may be as simple as assisting the victim to step out of the car into the ambulance. It may be as complicated as removing him on a spine board and up a brush-covered hillside.

Special Problems. Access, disentanglement, and removal from automobiles present special problems which require special instructions. Major points are given below.

Methods of gaining access and disentangling automobile parts and debris from around the victim require a great deal of common sense and ingenuity in the use of available methods and tools. While no two automobile crashes are exactly alike, similarities do exist.

Lighting is of utmost importance in many instances. It is impossible to work effectively in the dark or with inadequate lighting where injured persons are in serious danger.

Besides flashlights, each rescue vehicle must have floodlights capable of providing light at some distance from the vehicle.

Exercises (687):

1. Why is training in automobile rescue so very important?

2. What general rule of first aid may be disregarded during automobile rescues? When may this rule be disregarded?

3. Normally, extrication of victims from automobiles is divided into __________ stages, which are:

4. What is the main reason for hurried and possibly dangerous removal of victims from automobile wrecks?

5. What factors determine how access to a victim will be gained?

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6. What does the primary survey consist of during automobile rescue?

7. What is your primary concern in vehicle rescue?

8. What does disentanglement mean in automobile rescue operations?

9. What does the preparation for removal and removal of a victim from an automobile wreck entail?

688. Specify how to gain acess to automobile accident victims and disentangle them.

Gaining Access and Disentanglement. During access and disentanglement, great care must be exercised, because the tools usually are closest to the victim. Heat, noise, and force should be kept to the necessary minimum. Injuries the victim may have sustained should be taken into account to avoid making their condition worse. After access is gained and while disentanglement proceeds, efforts to give emergency care may continue as additional body areas become accessible for treatment.

A knowledge of mechanics and a familiarity with the available tools will facilitate access and disentanglement procedures. Prying, either manually or with powered equipment, is the method most frequently used on wrecked cars. Wrecking bars and crowbars will spread metal, open doors, or provide some other type of opening into the car. Where manual force is not sufficient, the hydraulic rescue kit with a spreader ram is used. An opening must be made or a present one enlarged to accommodate the jaws of the spreader. After a jammed door has been opened, two people should be able to rotate it completely out of the way by breaking the door check and, at times, the hinges. If a come-along is available, it should be used to remove the door from the hinges.

One of the difficulties that will be encountered in new cars is the metal safety lock which prevents prying the door open and often necessitates cutting the bolt before the door may be opened. One method used by automobile body mechanics is to cut a half circle around the door handle and turn back the resulting flap of metal, thus gaining access to the lock. (The door knob activates either a push rod or a metal plate, so there is no direct connection from knob to lock to prevent this.) The door jamb is then struck a heavy blow with a hammer at the lock, which relieves the tension on the bolt and allows the door to be opened.

Release of entrapped victims often involves lifting or pulling the car; at other times, parts of the car must be cut away. Needless to say, a knowledge of exactly how to cut away a car is important to avoid injury to an entrapped person. Without this knowledge, it might be better not to attempt such a procedure.

If a car is on its side, access through a door or window will allow surveying the victims and giving emergency care, but removing victims through such openings, although possible, is difficult. The top of the automobile may be turned down for removal of patients by cutting through the door posts or the top itself. Door posts may be cut through with a hacksaw, an air chisel, or a metal cutting saw. The air (pneumatic) chisel is much faster than any other feasible method.

The K-12 or Quickie saw is an effective tool for gaining access to the automobile. A disadvantage is the production of sparks, a distinct hazard when gasoline has been spilled. Hosing down the area before operating the saw may eliminate this hazard. With a power saw, the top of a car may be turned back in less than 5 minutes. Cuts should be made through the posts instead of the top itself. This is a faster procedure, creates fewer sparks, and gives more room to attend to persons inside. The size of the opening depends upon the automobile and the way the top is removed. Victims of the accident that are still inside the car should be treated and then covered with an asbestos blanket before starting cutting operations on the posts.

A simple but effective cutting tool is made of half the leaf from a car spring. One edge and the end are ground flat to produce a cutting surface and a handle is formed by wrapping the other end with rubber tape. It is used with a heavy mallet of fiber or rubber. The blade peels away a strip of metal and does not bind. It is not as fast as other methods, but it produces no sparks. The tool will cut around the top of a car so that it may be turned down with little effort. Easy access is thus provided to the interior of the car. Less room is afforded for reaching the victims inside the car than if the corner posts had been cut and the entire top turned back, but the room created is usually adequate. After cutting the top of the car, it is a simple matter to turn back the liner. Anytime an automobile is being cut with a victim inside, one rescuer should be on the inside with the victim to comfort him, explain what is being done to rescue him, and guide the individual who is cutting on the car.

The air chisel is by far the best cutting tool for use in automobile rescue. It is much faster than the K-12, produces virtually no sparks, and is exceptionally safe to operate. It uses air pressure (usually 300 psi) for its operation. A Scott air tank of air is sufficient to remove the top of a car. The pneumatic chisel "digs" its way into the metal of a car top. It is capable of fantastic speed in cutting the top of a car or a corner post.

The PTO (power takeoff) winch is of some value for automobile rescue. It is especially useful for areas where wrecker service is not quickly available. Carried outside the vehicle on the front bumper, it takes up no room which might be needed inside. It is used to pull open car doors, pull away crushed corner posts, and pull jammed seats back from dashboards. Winches are especially useful when the victim is trapped between the seat and the dash or steering wheel. Procedures in using the winch are as listed below:

(1) A chain is run around the seat and attached to the winch cable or grapnel.
(2) The rescue vehicle is positioned behind the car.
(3) The rear window of the wrecked vehicle is broken out and the cable passed through it.
(4) The rescue vehicle is braced with blocks against the car back.
(5) The winch is slowly and evenly taken in and the seat is torn from its track while a rescuer holds the victim in place to prevent sudden movement.

Exercises (688):

1. What is the most frequently used method for gaining entry into a wrecked car? How it is accomplished?

2. Newer cars will present you with a problem not encountered in older cars. What is this problem?

3. What does the release of entrapped victims often involve?

4. If a wrecked car is on its side and the victims inside have serious injuries, from which part of the car should they be removed? How is this made possible?

5. What tool opens a car top in the shortest amount of time?

6. Why is cutting the top of the car itself less desirable than cutting the door post for entry into a car?

7. What is the power takeoff winch used for in automobile rescue?

689. Specify how to prepare to remove and remove victims from automobiles.

Preparing for Removal and Removal. Preparation for removal of a victim entails immobilizing all fractures and dressing all wounds in addition to correcting all life-threatening problems. Use of standard splints in confined area is at times difficult or even impossible, but simple fixation of upper extremities to each other will suffice until initial movement of the victim provides sufficient space for adequate immobilization.

Making the victim into a package for movement as a unit is best accomplished by means of spine boards; the packaging converts difficult situations into easy ones. The boards are, of course, useful in moving victims with spine injuries, and they are very helpful in other cases as well.

The spine board should be applied to the victim before any movement if at all possible. If the victim of an automobile accident is unconscious, you should automatically assume that he has a spinal injury. If he complains of pain or discomfort, no matter how slight, apply the backboard.

The short spine board is used most frequently for stabilization of the sitting victim; besides being maneuverable, it provides handholds for easier movement. The head is supported, and the neck is immobilized by means of a cervical collar or other methods. The head is fastened in place by a head and chinstrap. The victim is secured to the body portion of the board by two long straps, applied across the chest and around the thighs, so that the weight of the body is supported and does not pull down against the straps on the head and chin. The victim may be lifted enough to slide a backboard under him and then secured to the backboard for removal.

If the victim is too large for this, he is removed by means of the long board which can be slid beneath him; sometimes the patient is slid onto the board. The board is highly polished, which makes the sliding action possible. Once the patient is on the board, the long straps are used for firm fixation so that the patient can be moved as necessary.

Ingenuity, common sense, and mechanical knowledge will solve most extrication problems. Part of the training of the rescue team members must consist of practice on wrecked cars from junk yards.

In attempting to slip a short spine board behind a victim seated in a car, you must exercise care and ingenuity to avoid disturbing the victim or having to move him before he is properly immobilized. It is possible to maneuver the board through the door and behind the patient. If the board strikes the top of the low doorway, it may be turned so that either end goes into the car first. It may then be pivoted into an upright position and slipped behind the victim. During this time, the victim remains undisturbed.

The following is the proper sequence in fixation of a suspected neck injury on a seated person. The cervical collar (or other means of immobilizing the neck) is applied, then the spine board is positioned behind the victim. The victim's head is fastened to the board with the chin strap and head band. The torso is fixed to the board by the two straps. The straps are passed through the upper handholds, behind the board, out the lower handholds on the opposite side, around the thighs from outside to inside, and finally under and over the thighs to the chest buckle. Keep the straps as close to the groin as possible.

Auto rescue is an area in which no two rescue operations will be the same. What may work for one wreck may prove ineffective on the next. That is the reason we must train on every way of auto rescue; the more we know of rescue work, the better we are. We must not only practice on gaining entry but also on treating victims and removal of the victim. The way we treat and remove a victim often tells if he will make the trip to the hospital ALIVE.

Exercises (689):

1. What is the best means of making a victim into a package for movement?

2. When should a spine board be applied to a victim?

3. The short spine board is most frequently used for what purpose?

4. How is a victim secured to a short spine board?

5. What can you use to solve most extrication problems?

690. Name the three major causes of drowning, and specify the procedures and precautions to take when attempting a water rescue.

Safety in, on, and about the water depends upon a number of things. It begins, of course, with the ability to swim well enough to care for one's self under ordinary conditions. It does not, however, end there. Real water safety is also based upon such things as the ability to recognize and avoid hazardous water conditions and practices. Ability to use self-rescue skills to get out of dangerous situations is also a factor. Finally, skill in rescuing or assisting persons in danger of drowning is a means of preserving one's own life, as well as saving that of someone else. The three major causes of drowning are, and always have been; failure to recognize hazardous conditions or practices, inability to get out of dangerous situations, and lack of knowledge of safe ways in which to aid or rescue drowning persons.

This course is not capable of training you in the practical aspects of water rescue. Being in the rescue business, you should recognize the fact that you may be called upon to make a rescue either on duty or off; and, due to the fact that you are a firefighter, you are expected to make the rescue successfully. It is recommended that every firefighter be trained in the American Red Cross Water Safety course. It is an excellent course and costs you nothing except the time you spend in it.

Capacity for Rescuing Others. The blind instinct to give assistance to a person in danger of drowning is innate in many people and prompts them often to deeds of heroism in attempting rescues for which they are poorly equipped. The tales of needless sacrifice in the history of swimming is a long one wherein the heroism displayed has availed to nothing. The parent, quite unable to swim, displays most frequently the blind courage which prompts him or her to rush to the aid of the child, to flounder into deep water where that child is in difficulty only to become a second victim and perish. Brothers and sisters, friends, or even total strangers often behave similarly with tragic consequences. Nor is this instinct to aid limited to nonswimmers. Novices and even very good swimmers frequently find that their ability to make rescue does not equal their good intent, and they either break away from the clutches of the drowning person or drown with him. In their desire to aid, they frequently ignore a perfectly safe means of effecting a rescue which is conveniently at hand and plunge blindly ahead, to attempt the rescue in the most perilous fashion.

Swimming requirements. A swimmer who wishes to undertake swimming rescue training must have reasonable swimming ability as a preliminary requirement. You should be able to make a shallow dive in good form and swim a quarter of a mile without resting or keep afloat by treading water and swimming in place for a period of 10 minutes. Your category of strokes should contain, as a minimum, a good side stroke, one of the hand-over-hand strokes (crawl, trudgen, or trudgen-crawl), and a fair semblance of a breast stroke. You should be able to swim with ease on your back, using your legs alone, for a distance of 20 yards or more. You should, of course, be capable of making a surface dive and of swimming a short distance underwater. Only if you are so equipped should you undertake this form of lifesaving training.

Knowledge and good judgment. Before swimming rescue training is actually begun, the learner should know something of the major circumstances which occur in drowning because, when a real emergency is faced, he must consider with lightening speed the proper course of action. First, the distance from shore and the depth of the water must be estimated to determine whether this may be a reaching, wading, equipment, or boat rescue, as the swimming rescue is resorted to only if no other means are available. Second, is the victim actually drowning, is he merely in distress and not in immediate danger? Third, what means are available for making the rescue? Fourth, what will the rescuer have to do in preparation for a swimming rescue if one is necessary?

If the victim is evidently a swimmer caught in a current, or one who is merely tired or panic-stricken, a slightly longer time interval may be allowed in going to the rescue. This time may be used to obtain a boat, to sprint along the shore to a point opposite the victim, or to get rid of clothing before plunging in. If the victim is alternately sinking and reappearing on the surface, time may be taken only to remove the more cumbersome outer garments and shoes before proceeding to the rescue. If a person sinks and fails to reappear at the surface, literally no time should be wasted in going to his assistance although the time required to divest one's self of outer clothing is a matter of but a few seconds.

Approaching a Victim. Contact with the victim is based on still more fixed principles. You must be in a position to seize the victim without being caught yourself, turn him about if necessary, bring his face above the surface so that he may breathe, level him off in a horizontal position, and put him into a carry. The victim is generally in a vertical position, head thrown back, arms extended forward and upward, clawing madly at the water. It is necessary, therefore, for you to avoid his grasp, put him under control, boost him to a horizontal position, and get under way for the carry. For the varying conditions under which these things have to be done, three types of approach have been devised. They are the rear approach, underwater approach, and front surface approach.

Anyone who has even the slightest interest in aquatics should know the kind of rescue for which he is fitted. Further, you should be able to size up a situation and use the best and safest means of helping the unfortunate victim if you are to preserve your own life. Everyone has the capacity to aid in some fashion, no matter what the degree of his aquatic skill. Furthermore, as his aquatic skills advance to ever higher levels, he should parallel this development with the practice of lifesaving skills commensurate with his steadily increasing water ability. Finally, no one should employ the more spectacular forms of rescue if less perilous methods may be used just as effectively.

Exercises (690):

1. What are the three major causes of drowning?

2. What is the preliminary requirement you must have to undertake water rescue?

3. When undertaking a water rescue, what is the first thing you must do?

4. When can you take a little extra time in going to a swimmer's rescue?

5. In what position is a drowning person normally found?

6. Why should you be able to size up a situation and be able to use the best and safest means of helping a victim?

691. Specify the firefighters role in performing rescue after a natural disaster.

Being in the rescue field may necessitate your presence at the scene of a natural disaster. During a natural disaster (and thereafter), the public will need all the help that is available. You will be working under far different conditions than you have ever worked under. You will also probably be working for a different boss.

A natural disaster is a disaster caused by nature or the natural elements—floods, tornadoes, hurricanes, earthquakes, etc. In any of these situations, your first concern will be to survive; then you must help others to survive. After the situation has subsided, you will restore the base to operation (where we are concerned, we make sure all base rescue business is taken care of), then we will probably be called upon to assist the local community. When you leave the base, you are responsible to the Civil Defense officials in your capacity as a rescue team member. They will direct you as to where to start, where the victims will probably be trapped or located, when to terminate your mission, etc. You will be working in the operation jointly with local rescue, police, fire, and other civil servants in their attempts to rescue entrapped personnel.

In these situations, you will be called upon to use all of your knowledge and skills to effect rescues. You cannot use only those skills developed in any one area, such as aircraft rescue, structural rescue, or vehicle rescue. You must be able to combine any or all of these skills in order to get the job done and done right.

Any situation that you think of that may require rescue should be planned for and training done accordingly. Safety, for yourself and the victims, and training are the two most important items in the business of rescue. Without these two, you may as well stay in the station.

Exercises (691):

1. What will be your first concern during a natural disaster?

2. After a natural disaster has subsided and you are assisting a local community in rescue operations, to whom will you be responsible?

3. Which knowledges and skills will you have to employ as a result of a natural disaster?

4. What are the two most important items in the rescue business?

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Answers For Exercises

CHAPTER I

Reference:

600 - 1. The brain suffers irreparable damage within a few minutes.
600 - 2. Brain.
600 - 3. The brain does not get enough oxygen to survive, and the signals that regulate the heart and lung activity slow down and stop.
600 - 4. The degree of airway obstruction.
600 - 5. 4 to 6 minutes.
600 - 6. The muscles that control the lower jaw and tongue relax, allowing the tongue to drop against the back of the pharynx and over the larynx.
600 - 7. Automatic reflexes.
600 - 8. A flexed neck and foreign matter.

601 - 1. Look for breathing movements, listen for airflow at the mouth and nose, and feel for air exchange.
601 - 2. Involuntary muscular action may cause continued chest movement.
601 - 3. By placing your ear close to the patient's mouth and nose to hear and feel the exchange of air.
601 - 4. By listening.
601 - 5. Tongue.
601 - 6. Gurgling.
601 - 7. By a noticeable blue or gray color in the tongue, lips, nail beds and skin. A patient with a dark skin may show this coloring in the mouth, mucous membrane, or inner surface of the lips and eyelids.

602 - 1. Your finger.
602 - 2. First priority over all other emergency first aid.
602 - 3. The neck will be flexed and perhaps block the air passage even more.
602 - 4. He should be placed on his back and his head tilted backward as far as possible.
602 - 5. Try to force two or three good-size breaths quickly into the patient's lungs through the mouth.
602 - 6. The airway is unobstructed.
602 - 7. By using one of the two jaw-lift methods.
602 - 8. You grasp the angles of the patient's jaw and pull with both hands just below the ear lobes to lift the jaw forcibly upward so that the teeth on the lower jaw are in front of the teeth on the upper jaw.
602 - 9. A foreign object lodged deep in the patient's throat.
602 - 10. You try to reach the object with your extended finger. If this fails, attempt to dislodge the object by turning the patient on his side and administer a few sharp slaps between the shoulders.
602 - 11. Hold him upside down and give him a few sharp blows between the shoulders.

603 - 1. 100 percent.
603 - 2. The left ventricle.
603 - 3. One inch.
603 - 4. In the early stages of hemorrhage and in states of shock.
603 - 5. At the carotid artery in the neck or the femoral artery in the thigh.
603 - 6. 70.
603 - 7. There are so many factors which will cause the heartbeat to change.
603 - 8. Every 2 or 3 minutes.
603 - 9. Bleeding, shock, or any number of other conditions.

604 - 1. One minute.
604 - 2. 12.
604 - 3. 4 pints.
604 - 4. 5½ gallons per minute.
604 - 5. The blood is not flowing as fast.
604 - 6. The speed at which the blood flows.

605 - 1. The pressure methods and the tourniquet.
605 - 2. By direct pressure or digital pressure.
605 - 3. Direct pressure.
605 - 4. You merely apply pressure directly to the wound.
605 - 5. By extending the fingers directly into the wound and compressing the bleeding vessel.
605 - 6. You should apply digital pressure.
605 - 7. Directly to an artery at the pressure points.
605 - 8. Four, two on each side of the body.
605 - 9. On the angle of the lower jaw where the artery crosses it.
605 - 10. The femoral artery.
605 - 11. In the center of the knee cavity.

606 - 1. When severe, life-threatening hemorrhage cannot be controlled by any other means. More specifically, only in cases of partial or complete severance of a body part.
606 - 2. It completely shuts off the entire blood supply to the part of the body to which it is applied.
606 - 3. Physicians or medical personnel who are prepared to control hemorrhage and replace blood volume.
606 - 4. Narrow objects tend to cause injury to the underlying tissues and blood vessels.
606 - 5. Coughed up blood will be bright red and frothy; vomited blood has the appearance of coffee grounds.
606 - 6. Figure an approximate 10 percent blood loss for each area of badly contused tissue the size of a man's fist.

607 - 1. The failure of the cardiovascular system to provide sufficient blood circulation to every part of the body.
607 - 2. When the cardiovascular system loses its volume or the vessels dilate so widely that there is not sufficient blood to fill the system.
607 - 3. Stimuli, such as heat, cold, or fear; not human will.
607 - 4. Dilation of the blood vessels, a loss of blood, or failure of the heart to circulate the blood properly.
607 - 5. They begin to die.

608 - 1. Hemorrhagic shock.
608 - 2. There is not sufficient blood to fill the system; thus, the circulation is impaired.
608 - 3. Insufficient oxygen in the blood.
608 - 4. Neurogenic shock.
608 - 5. The muscles controlled by the nerves, including the muscles of the blood vessel walls, are temporarily or permanently paralyzed, causing impairment of circulation.
608 - 6. Fainting.
608 - 7. A reaction of the nervous system to certain stimuli.

608 - 8. Septic shock.
608 - 9. Loss of body fluids and changes in body chemistry.
608 - 10. Septic and metabolic.

609 - 1. The eyes are dull and lack luster; the pupils are dilated; the face is pale and may be cyanotic; respiration is shallow, possibly irregular, or labored; the pulse is weak and rapid; the skin is cold and clammy; and there may be nausea, collapse, vomiting, anxiety, and thirst.
609 - 2. Assure adequate breathing, control bleeding, elevate the lower extremities, avoid rough handling, prevent loss of body heat, keep the victim lying down, and give nothing by mouth.
609 - 3. This avoids exertion on the circulatory system.
609 - 4. Nothing.

610 - 1. Each other.
610 - 2. The lungs enrich the blood with oxygen which the heart pumps to the brain. As long as the cardiac control center in the brain has a fresh supply of oxygen, it will cause the heart to pump blood through the lungs for oxygen enrichment.
610 - 3. No oxygen is available to the blood stream.
610 - 4. Clinical death occurs at the moment heart action, respiration, and other usual signs of life cease; however, a patient may be revived by prompt positive action. Biological death occurs a period of time after clinical death when the brain cells die due to lack of oxygen. There is no return from biological death.
610 - 5. 4 to 6 minutes.

611 - 1. The combination of efforts to restore breathing and circulation artificially.
611 - 2. The manual method.
611 - 3. In order to perform the techniques of CPR properly.
611 - 4. By compressing the chest from 1½ to 2 inches.
611 - 5. The elastic chest wall.
611 - 6. 35 percent.

612 - 1. By the ABC technique.
612 - 2. A stands for airway, B stands for breathe, C stands for circulate.
612 - 3. The entire body will be pushed down when attempting chest compressions if it is not on a hard surface.
612 - 4. In the center of the lower half of the sternum.
612 - 5. CPR will not be effective, and the pressure may result in damage to other structures.
612 - 6. The heel of one hand is placed over the pressure point, and the heel of the other hand is placed over the back of the first hand.
612 - 7. 1½ to 2 inches.
612 - 8. 60 to 80.
612 - 9. Until you are relieved by qualified personnel or the patient shows signs of recovery.
612 - 10. Some means of artificial ventilation.
612 - 11. The cycling of the machine can be interrupted by the chest compressions.
612 - 12. An airway is immediately established, and the patient is ventilated.
612 - 13. Every 15 chest compressions.
612 - 14. Two; no pause.

613 - 1. With two first-aiders working together.
613 - 2. One person is positioned at the patient's head and the other is at the patient's side opposite the first person.
613 - 3. Every five chest compressions.
613 - 4. One hand should be used to support the head, and the tips of the fingers of the other hand are used for chest compressions.
613 - 5. The mouth is placed over the mouth and nose of the patient, and puffs from the cheeks are blown in.

614 - 1. The pupils of the eyes must constrict, the patient's color must improve, and a pulse must be felt at the carotid artery with each compression.
614 - 2. A change in the size of the pupils and a freshening in skin color of the patient.
614 - 3. The heart-lung-brain relationship has been restored and is returning to normal.
614 - 4. The ribs may be fractured and may cause lacerations to the lungs and possibly the heart itself.
614 - 5. The liver.

615 - 1. Pulmonary.
615 - 2. It may be applied in almost any situation immediately by one person and requires no special equipment. The lungs are provided with maximum ventilation, and the first-aider's hands are free to maintain an airway, etc., it is easier to gage the effectiveness of efforts, and it is less fatiguing.
615 - 3. There is nothing to find, set up, or malfunction.
615 - 4. You may use them to maintain an airway, expel air from the stomach by compressing it, and feel for a pulse in the carotid artery.
615 - 5. You can feel the lungs expand, see the chest rise, and hear the air escape during exhalation.

616 - 1. By maximum extension of the head.
616 - 2. By pinching the victim's nose shut with your thumb and forefinger.
616 - 3. When you feel the resistance of the victim's expanding lungs and see his chest rise.
616 - 4. Twelve times a minute (every 5 seconds).
616 - 5. To assure adequate oxygenation of the blood and removal of carbon dioxide from the patient's lungs.
616 - 6. Twenty.
616 - 7. By using your cheek or placing a finger over them.
616 - 8. When attempts to penetrate air through the victim's mouth have failed.
616 - 9. So you will know what procedures must be used on each.
616 - 10. Clearing the mouth is not necessary, and extension of the head may not be necessary.

617 - 1. Curved breathing tubes which, when inserted properly, hold the base of a victim's tongue forward so as not to block the air passage.
617 - 2. When a patient is found conscious and breathing normally or when head tilt or other artificial ventilation will clear an air passage.
617 - 3. The airway is inserted between the victim's teeth with the curve backward at first; then it is turned to the proper position as it is inserted deeper.
617 - 4. Hold the tongue forward with your index finger.

618 - 1. To overcome objection to direct mouth-to-mouth contact.
618 - 2. By pressing the flange firmly over the mouth.
618 - 3. Double-size breaths.
618 - 4. Failure of the operator to hold the facepiece firmly enough against the patient's face to ensure an adequate seal.
618 - 5. After placing facepiece over the victim's face, clamp securely in place with one hand by pressing your thumb over the rim of the mask and by placing your index finger over the chin part. Use your third, fourth and fifth fingers to pull the victim's chin upwards and backwards.
618 - 6. About once every 5 seconds.
618 - 7. Hold the mask tighter and squeeze the bag harder.
618 - 8. Signs of vomiting. Because continuing operation will force vomitus into the patient's trachea.

619 - 1. After the immediate problems are out of the way.
619 - 2. To determine the full extent of his injuries and the cause.
619 - 3. Only when absolutely necessary.
619 - 4. Both over and under the individual.
619 - 5. The kind of accident or sudden illness.
619 - 6. There may be spinal injuries.

619 - 7. By checking the color of the inner surfaces of the mouth, lips, or eyelids, or mucous membrane.
619 - 8. Try the artery at the side of the neck.
619 - 9. By using your fingertips. Never use your thumb.
619 - 10. Paralysis and signs of recent convulsions.
619 - 11. The expression of the eyes and size of the pupils.
619 - 12. Stains or burns in or around the mouth and a source of the poison.

620 - 1. Covering wounds.
620 - 2. By securing a small corner of the dressing between the thumb and index finger and pulling it free.
620 - 3. An adhesive compress.
620 - 4. A dressing and bandage for wounds. By tying the tails of the bandage.
620 - 5. Because they can be applied neatly and snugly over the irregular surfaces of these parts.
620 - 6. It will impede circulation.

621 - 1. Bring the apex of the triangular to the center of its base and continue to bring apex folds down to base line until desired width is attained.
621 - 2. Body support and arm slings.
621 - 3. Across the middle of the palm with the thumb on top.
621 - 4. Opposite side from the compress it is covering.
621 - 5. The place where the tie is made.
621 - 6. Right angle (90° angle).
621 - 7. It is carried entirely around the arm above the elbow and brought back to the hollow.
621 - 8. At the outside edge of the hollow.

622 - 1. Behind the elbow of the injured arm.
622 - 2. To permit one to observe whether or not the circulation is cut off.
622 - 3. Two to three inches above the level of the elbow.
622 - 4. The hand should be placed so that the middle of the bandage comes well up the wrist.
622 - 5. The ends are crossed around the wrist and tied.
622 - 6. The bump at the back of the head.
622 - 7. The apex is turned up and tucked in where the bandage crosses.
622 - 8. The apex is placed over the shoulder on the injured side. The bandage is then carried down over the chest or back so that the center of the base is directly below the shoulder.
622 - 9. A knot is tied about 6 inches from the apex of the bandage. The knot is then placed on top of the head with the base being carried down the back of the head. Both ends are brought to the front of the neck and crossed and taken to the back of the neck to be tied.
622 - 10. Centered over the injured shoulder.
622 - 11. Around the arm on the injured side.

623 - 1. An incision.
623 - 2. The depth of the incision and the vessels that have been severed.
623 - 3. A laceration.
623 - 4. Because of the stretching and tearing of the blood vessels and possiblility of severe bleeding.
623 - 5. A puncture is the result of the disruption of the skin and underlying tissue by a pointed object such as a nail or ice pick.
623 - 6. Penetration and perforation.
623 - 7. The perforation.
623 - 8. Every effort should be made to preserve it and transport it to the hospital with the victim.
623 - 9. A snug pressure dressing over the stump.
623 - 10. There is a strong tendency for the crushing action to close off the bleeding vessels effectively as they are severed.

624 - 1. The impact of a blunt object.
624 - 2. 24 to 48 hours.
624 - 3. Blood seeping into the surrounding tissues.
624 - 4. A pressure dressing.
624 - 5. The removal may cause further damage to nerves and muscles and/or may cause severe hemorrhage.
624 - 6. When necessary to perform CPR, or it interferes with the victim's breathing.
624 - 7. Stabilize the object with large bulky dressings.
624 - 8. A sitting position with the head and shoulders raised.
624 - 9. Place the victim in the supine position and apply cold, wet towels.
624 - 10. One-half inch.

625 - 1. The negative pressure required for operation is lost.
625 - 2. It collapses.
625 - 3. It is pushed over toward the good lung as the patient breathes in, thus interfering with it.
625 - 4. The patient will be spitting or coughing up bright red, frothy blood.
625 - 5. Seal the hole in the chest.
625 - 6. On his injured side.
625 - 7. Air pressure within the chest cavity builds up to such a degree that collapsed lung is pressed firmly against the good lung and heart, interfering with their action.
625 - 8. Transport him immediately to hospital.

626 - 1. The joints above and below the fracture.
626 - 2. Open and closed.
626 - 3. The way the bone is broken.
626 - 4. Oblique.
626 - 5. A break split along the length of the bone.
626 - 6. The bones are broken, then jammed into each other.

627 - 1. A splint is any material or appliance that can be used to immobilize a fracture or dislocation.
627 - 2. Rigid and traction.
627 - 3. It must be long enough so that it can be secured well above and below the fracture site to include the joints.
627 - 4. They do not extend past the upper joint in either case.
627 - 5. By mouth only.
627 - 6. You should be able to make an indentation in the splint easily with your thumb.

628 - 1. Ingested.
628 - 2. Inhaled.
628 - 3. Absorbed.
628 - 4. Injected.

629 - 1 Strong acid or alkali or petroleum product.
629 - 2. Milk, milk of magnesia, or water.
629 - 3. The collected vomitus and poison container, if it can be found.
629 - 4. It unites with the red blood cells much more readily than does oxygen and is colorless, odorless, and tasteless.
629 - 5. The skin takes on a cherry-red color that is unlike any other symptom of illness.
629 - 6. Remove the patient to fresh air and start oxygen inhalation immediately, preferably with a bag-mask resuscitator.
629 - 7. Flush the affected area with water.
629 - 8. At least 15 minutes.

630 - 1. Block the flow of the poison to the heart.
630 - 2. The coral snake.
630 - 3. Tetanus germs.
630 - 4. Have the victim stop all muscular activity at once. Tie a constriction band firmly above the bite, if it is on an extremity. Make 1/8- to 1/4-inch-long cuts, with a sterile instrument, through each fang mark. (Cuts should be 1/8- to 1/4-inch deep.) Apply suction at intervals for an hours or more, and get medical attention as soon as you can.

631 - 1. A superficial injury characterized by reddening of the skin.
631 - 2. Third degree.

631 - 3. Third degree.
631 - 4. The growth cells are destroyed, and new skin can only grow from the outer edges to the center.
631 - 5. To treat for shock.
631 - 6. A dry protective bandage of clean cloth or sterile gauze.
631 - 7. It may intensify shock reaction.

632 - 1. Alkali.
632 - 2. Flush the chemical away with water.
632 - 3. Flush the eyes with large amounts of water; apply sterile compresses to both eyes; transport to medical facility.
632 - 4. They often involve deep layers of skin, muscles, and even internal organs.
632 - 5. CPR.

CHAPTER 2

633 - 1. The drag is used when the victim is near an exit, if the victim is extremely heavy, or where a lack of headspace makes other carries impractical.
633 - 2. The victim is placed on his back, the grasped beneath the arms and moved backward; or the victim is placed on a suitable item, such as bunker coat or blanket, and pulled to safety.
633 - 3. In the direction of the long axis of the body.
633 - 4. When the victim is to be moved up or down stairways.
633 - 5. The injuries and weight of the victim.
633 - 6. When you are equipped with a self-contained breathing apparatus.

634 - 1. Face down.
634 - 2. Against the victim's midsection.
634 - 3. To prevent injury to yourself.
634 - 4. The victim can be carried considerable distances without fatigue, and you will have your left hand free for other uses.
634 - 5. The fireman's carry cannot be made when you are equipped with a self-contained breathing apparatus.

635 - 1. The victim is grasped under the back with one arm and under the knees with the other arm. The victim is then lifted to a high position on the carrier's chest to reduce fatigue on the carrier.
635 - 2. A broken back or leg.
635 - 3. The carriers' arms locking together.
635 - 4. When going up or down stairs, through narrow hallways, etc.
635 - 5. One carrier grasps the victim by the legs while the other carrier grasps the victim under the arms and around the waist.
635 - 6. No serious injuries to the body.
635 - 7. Three.
635 - 8. The victim must be transported with the least possible bending or twisting of their body.
635 - 9. The individual at the victim's head.
635 - 10. One carrier (the leader) is at the victim's shoulders, the second carrier at the victim's hips, and the third carrier below the victim's knees. All three carriers are on the same side of the victim.

636 - 1. Five.
636 - 2. The leader is on one or both knees at the victim's head, looking down the length of the victim's body.
636 - 3. Each member places one of his hands flat under the victim's shoulder blade and the other hand in the victim's armpit.
636 - 4. Team members four and five.
636 - 5. The blanket is rolled tightly at the sides until it fits the contour of the victim's body.
636 - 6. 6 to 8 inches.
636 - 7. One member at approximately the shoulder; one at the victim's hips on the same side as the first, and one opposite and between the other two team members at approximately the victim's waist.
636 - 8. The knee nearest the victim's feet.
636 - 9. One arm is slid under the victim's thighs above member #2's bottom arm, and the other arm is placed under the victim's legs below the knees.
636 - 10. To the team members' knees while they are still kneeling.

637 - 1. To move the spine board.
637 - 2. Maintaining constant traction on the victim's head and neck.
637 - 3. To prevent the arm from obstructing the rolling movement.
637 - 4. When the leader is satisfied that proper traction is being applied and that all team members are ready to make the roll.
637 - 5. At points where voids will be created when the victim is rolled onto the spine board. To support areas of the body that do not contact the board.
637 - 6. Only after the victim has been rigidly immobilized on the board.
637 - 7. With straps or cravats at the chest, thighs, and knees. A cravat is placed across the forehead to prevent movement of the head.
637 - 8. The padding of the voids.

638 - 1. When a victim is suspected of having spinal injuries and it is impossible to use the four-man log roll, such as in a narrow hallway or between immovable objects.
638 - 2. In all cases where injury to the spine is suspected.
638 - 3. The team leader stands at the victim's head (facing the victim's feet) with feet spread wide enough to allow for passage of a spine board between them.
638 - 4. The third team member straddles the victim just below the waist so that when he bends over, the hands will be at the victim's waist.
638 - 5. Just high enough for the spine board to pass under.
638 - 6. In one smooth and unbroken movement.

639 - 1. The sleeves should be pulled wrong-side-out and left inside the coats. Fasten the snap-fasteners in the normal manner and lay the coats down. The snap-fasteners should be on the bottom and the collars touching each other. A pike pole is then inserted through the coats (being sure to go through the turned sleeves).
639 - 2. By the weight of the victim.
639 - 3. To be sure the stretcher will withstand the weight of the victim.
639 - 4. Four.
639 - 5. All bearers should face in the same direction, with the bearer at the victim's feet facing the victim's head. So that the victim may be watched for signs of discomfort or a change in his condition.
639 - 6. You descend the ladder with one arm on each side of the victim, talking to him on the way down.
639 - 7. To reassure the victim that he is being taken to safety and to help dispel any fears he may have of ladders.

CHAPTER 3

640 - 1. To have skilled rescue personnel ready to perform when needed.
640 - 2. Educationally, mentally, and physically.
640 - 3. Your ability to learn new techniques and retain past knowledge for use in other emergency situations.
640 - 4. Physical endurance, self control, and competent skills.

641 - 1. Daily and after each use with a complete operational test every 90 days.
641 - 2. By opening the regulator bypass valve.
641 - 3. Finger-tight.
641 - 4. You inspect the valve for damage and/or obstructions and test the valve by operating it.
641 - 5. The buckles and/or fastening devices.

641 - 6. The wrench and operating instructions, and any forms or inspection check sheets required.
641 - 7. The left side strap.

641 - 1. The red knob should be in the CLOSED position, and the yellow knob should be in the fully OPEN position.
642 - 2. You should use the lower pressure reading.
642 - 3. 400 psi.
642 - 4. 2000 psi.
642 - 5. You turn the cylinder valve open three full turns and lock. Then place your thumb over the mask connection coupling on the regular, open the regular valve, and check the regulator pressure gauge. Compare the reading from the regulator pressure gauge with that from the air cylinder pressure gauge.
642 - 6. Open the cylinder valve three full turns and lock. Place your thumb over the mask connection coupling on the regulator, and open the regular valve. Open the regular bypass valve. With bypass valve open, air should be forced past your thumb. With bypass valve closed, no air should escape past your thumb.
642 - 7. 540 psi.

643 - 1. The neck straps.
643 - 2. By holding the thumb over the breathing tube and inhaling slowly.
643 - 3. Only when you fail to get an adequate air supply.
643 - 4. It provides a continuous flow of air bypassing the regular mechanism.

644 - 1. You should check the pressure remaining in the cylinder to be filled.
644 - 2. By opening and closing the valves on each storage cylinder and reading their pressure gauges.
644 - 3. The cylinder with the lowest pressure above the pressure of the cylinder to be filled.
644 - 4. A full storage cylinder should be put in place of the storage cylinder with the lowest pressure.
644 - 5. By marking the amount of pressure remaining in each storage cylinder on the side of the cylinder in chalk.

645 - 1. The ballpeen hammer.
645 - 2. You should grind it to its original shape.
645 - 3. Using the wrong size wrench for the size of pipe, using the wrench as a hammer, using the wrench on nuts and boltheads, and using cheater bars on the handle.
645 - 4. So that they will grip.
645 - 5. Keeping them clean of grease and grime, preventing rust, and maintaining the tips.

646 - 1. Removing nuts or bolts or as pry bars.
646 - 2. The adjustable combination pliers, the half-round nose, and the round nose.
646 - 3. Toward the user.
646 - 4. The machinist's cold chisel.
646 - 5. A light coat of oil.

647 - 1. Wood or fiberglass.
647 - 2. 8 foot.
647 - 3. During all hazardous operations where damage to the eyes is possible.
647 - 4. They crystallize when in contact with these substances.
647 - 5. To prevent accidental firing of escape systems; to further safety the egress systems in aircraft; and for use with salvage covers.

648 - 1. To unlock Dzus fasteners.
648 - 2. To cut wire or cable.
648 - 3. 3/8 inch.
648 - 4. 14,000.
648 - 5. Diagonally rather than with the grain of the wood, using short, quick, forceful strokes.
648 - 6. The axe may bind and will require time and effort to withdraw it.

649 - 1. It is designed to cut the hose that leads from the catapult initiator to the catapult explosive charge.
649 - 2. To keep the hose in position while the handles are brought together.
649 - 3. Hard rubber and hardwood.
649 - 4. Conical.
649 - 5. Two.

650 - 1. So that it won't jam or stick in the cut it has made.
650 - 2. The blade stops on each side of the blade.
650 - 3. Neat's-foot oil.
650 - 4. Up to 5/8-inch diameter, except for specially hardened stock.
650 - 5. The tightening bolts should be adjusted periodically.
650 - 6. Improper use, such as trying to cut hardened steel.
650 - 7. The clawbar.
650 - 8. In cases requiring heavy prying or great strength.
650 - 9. It should be turned in for another one. DON'T try to straighten it.

651 - 1. The hook.
651 - 2. The tapered tip.
651 - 3. By using the thin part of the tip for heavy prying or pulling tasks.
651 - 4. The door opener, crowbar, and hatchet.
651 - 5. By removing the claw section of the handle and inserting it in the hole in the side of the head.

652 - 1. 1000 watts at 3600 RPM.
652 - 2. The generator engine is extremely hard to start with a load on it.
652 - 3. It will overheat.
652 - 4. Quartz-iodide.
652 - 5. 50 feet.

653 - 1. To remove smoke and fumes from enclosed areas.
653 - 2. Between 2000 and 2400 RPM.
653 - 3. One part oil to 10 parts gasoline.
653 - 4. It is used to lift objects or spread parts in rescue operations.
653 - 5. 11,000 pounds.

654 - 1. An engine driven hydraulic pump.
654 - 2. Ninety-five pounds—40 pounds for the pump and engine and 55 pounds for the tool.
654 - 3. Five tons (10,000 pounds).
654 - 4. By thumb pressure.
654 - 5. By using special application snap-on jaws.

655 - 1. By air pressure.
655 - 2. A breathing apparatus air bottle.
655 - 3. It is used for pushing, spreading, and bracing.
655 - 4. Anchor the "come-along" to a frame member and use it to pull the entire steering column free of the victim.

656 - 1. 6 horsepower at 6000 RPM.
656 - 2. To transmit power to the cutter blade.
656 - 3. Carbide tip, metal, and concrete.
656 - 4. With a mixture of oil in the fuel.
656 - 5. TO 36A12-12-13-1 or TO 36A12-12-13-11.

657 - 1. The proper fuel mixture—the right grade of gasoline and the right type of quality oil, both in proper ratio.
657 - 2. The results will be poor performance and the formation of lead deposits in the combustion chamber and on the spark plug.
657 - 3. Automotive or reclaimed motor oils.
657 - 4. The engine will run unevenly, the oil may foul the spark plug, and power loss can result.
657 - 5. Stored fuel will collect moisture and lose strength, resulting in poor engine performance.
657 - 6. 4 U.S. gallons.

658 - 1. By a spring-loaded guard sheath.
658 - 2. To give two-handed stability as you guide and apply force to a cut.
658 - 3. 6 and 8 inches.
658 - 4. Daily.

659 - 1. The normal entrance door (s).
659 - 2. Check for an unlocked window.
659 - 3. By forcible entry.
659 - 4. Doors, windows, roofs, and walls.

660 - 1. To make successful forcible entry.
660 - 2. First by the manner in which the door is hung and secondly by how it is locked.
660 - 3. Try the door to see if it is locked.
660 - 4. They may be horizontal, vertical, or a combination of both.
660 - 5. They may be mounted on the surface of the door or installed in the door itself.
660 - 6. On warehouses, storerooms, and barns.
660 - 7. With surface locks—hasps and padlocks, bolts, or bars.
661 - 1. On a metal track with small rollers or guide wheels.
661 - 2. The "patio-door".
661 - 3. By inserting a wedge tool between the jamb and door near the lock and prying the door away from the frame.

662 - 1. By checking the door hinges and jamb.
662 - 2. Between the door and the jamb near the lock.
662 - 3. Away from the door.
662 - 4. Either by pulling or by prying open with a second tool.

663 - 1. The door may be separated from the jamb sufficiently to permit the bolt to pass the keeper.
663 - 2. To break the paint or varnish so that the blade can be inserted.
663 - 3. Halfway in.
663 - 4. Two.
663 - 5. The first tool is used to open a crack between the door and the rabbet so that the second tool can be inserted to force the door away from the jamb.
663 - 6. Lay the blade of one tool flat against the door and insert the blade between the rabbet and the door. Using short prys of the first tool, work the blade of the second tool between the door and the jamb. (Be sure you work the blade of the second tool well into the opening). With a full bite of the blade of the second tool behind the door, pry the jamb away from the door until the bolt passes the keeper.

664 - 1. Because of the manner in which the door and door jamb are constructed.
664 - 2. It is constructed entirely of metal.
664 - 3. The special installations that place two bars on the doors, one at the top and one on the bottom.
664 - 4. How it is LOCKED.
664 - 5. You must feel the door for heat by using the back of the hand. Because the back of the hand is more sensitive to heat.
664 - 6. By inserting a wedge tool between the two doors at the lock and prying the doors apart.
664 - 7. When the swinging doors are secured with a bar on the inside that is dropped into stirrups or hooked on the inside wall.

665 - 1. Because of the heat treatment given to the glass during tempering.
665 - 2. By striking it with the pick point of a standard fire axe.
665 - 3. You should wear protective clothing and a face shield. If there isn't a face shield available, turn your head and face away from the door as the glass is being broken.
665 - 4. They have relatively little breaking effect.
665 - 5. The doors consist of quadrants that revolve around a center shaft. The revolving wings turn within a metal or glass housing which is open on each side and through which pedestrians may travel as the door is turned. Each of the wings is held in position by hangars at the top and bottom of the wing.
665 - 6. The wings fold to a wide open panic position when the hangars are collapsed or when force is exerted in opposite directions on any two wings. Since all revolving doors do not collapse in the same manner, it is good policy to gather information on each type used during fire inspections.

666 - 1. The latch is usually in the center of the door, but may also be found on the side.
666 - 2. Near the top of the door on the inside wall.
666 - 3. The gear arrangement and its location.
666 - 4. Pry outward with a bar at each side of the door near the bottom.
666 - 5. Garage doors.
666 - 6. They drill a hole in the lock bar after it has passed through the door track and put a padlock through the hole in the bar to further secure the door.
666 - 7. Break the glass in the panel nearest the latch. Reach through the broken window and unlock the door from the inside.

667 - 1. Prying with a wedge tool.
667 - 2. Aluminum frames are usually damaged beyond repair.
667 - 3. By breaking the glass in the window, removing the glass pieces, and reaching in to unlock and open the window.
667 - 4. To assure safety to the firefighter.
667 - 5. Stand on the South side of the window with your body facing West; this will put the window to your right. Swing the breaking object toward the window and turn your face and head to your left (South) just before the glass is broken.
667 - 6. The HANDS.

668 - 1. Casement windows consist of one or two sashes which are hinged on the side and swing outward from the window.
668 - 2. Some windows are operated by cranks; others have a notched push bar.
668 - 3. The screen, if installed, must be removed
668 - 4. Break the lowest pane of glass and clean out the sharp edges. Cut or force the screen in the same area and reach in through the hole to unlock the window and operate the cranks and levers at the bottom.

669 - 1. Checkrail windows are made of wood or metal and usually consist of two sashes that slide in tracks formed in or by the window frame itself. The upper and lower sashes meet in the center. They may or may not have a locking device in the center of the checkrail.
669 - 2. The screws attaching the locking device will pull out of the wood with little force.
669 - 3. Insert a wedge tool between the lower sash and the sill at the center of the window. Pry the lower sill up until the screws attaching the locking device are pulled out of the wood.
669 - 4. Two.

670 - 1. At the top, bottom, or in the center.
670 - 2. The type of lock usually reveals the direction the window is to be projected.
670 - 3. Use the same procedure as for casement windows. Break the window near the lock and clean out the sharp edges. Cut or remove the screen (if one is installed), and reach through to unlock and open the window.

671 - 1. Because of their methods of operation.
671 - 2. The awning windows consist of long sections of glass about 1 foot wide and as long as the window width; jalousie windows consist of small sections of glass about 4 inches wide and as long as the window width.

671 - 3. Even with the louvers open, there is not enough room between the louvers for a person to enter. Therefore, several of the panels must be broken out or removed to allow entry.

672 - 1. Forcing the wire mesh guards involves a considerable amount of time.
672 - 2. About 10 inches.
672 - 3. By forcing the pick end of an axe between the sill and the grating and then prying up.

673 - 1. Those that are trapped on the premises.
673 - 2. Members of the family, other employees, neighbors of the family, and bystanders.
673 - 3. To insure that someone did not enter the building without the knowledge of the occupants and remains there.
673 - 4. You should work in pairs and be equipped with a breathing apparatus and a lifeline.
673 - 5. So you will not get lose or search the same area twice.
673 - 6. The first arriving crew.
673 - 7. In case of fire, the search should begin on the fire floor and then move to the floors above. In case of no fire, the search should begin at the lowest level of the building and move up.
673 - 8. On your hands and knees. Follow the walls. By reaching out with the outside hands and feet as far as possible.
673 - 9. Under beds, behind furniture, and in closets.
673 - 10. By flipping the mattress on the bed into a "U" position.
673 - 11. By throwing a helmet outside to the ground.

674 - 1. As soon as conditions permit.
674 - 2. Thoroughness.
674 - 3. This movement may cause injury or death to victims underneath the rubble.
674 - 4. By making calls from selected points and then maintaining a period of complete silence to listen for sounds from victims.
674 - 5. Yelling will only excite a victim.
674 - 6. The initial size-up, initial decision, and the development of supplemental decisions.
674 - 7. When the search and rescue work is to be inside.

675 - 1. The type of aircraft and its configuration.
675 - 2. The location of the aircraft crew during air and ground operations under normal conditions.
675 - 3. Always in the cockpit.
675 - 4. The normal crew positions.
675 - 5. Any position other than the normal crew position to which a crewmember is required to go for an emergency landing, crash landing, ditching, or other dire emergency
675 - 6. Aircraft with boom operators and tail gunners.

676 - 1. On either side, bottom, or top of the aircraft, depending upon the type involved.
676 - 2. On the pilot's left since this is the rescue side on most aircraft.
676 - 3. Time.
676 - 4. Through practice.
676 - 5. Through the canopy is the ONLY way.
676 - 6. Through electrically, hydraulically, or pneumatically operated canopies.

677 - 1. Over the wings and along the fuselage.
677 - 2. The ones over the wings.
677 - 3. Through the canopy by jettison or cut-in.
677 - 4. Only when normal and manual means have failed.
677 - 5. Cutting in.
677 - 6. Large frame aircraft with the wings on top of the fuselage.
677 - 7. Cockpit windows.

678 - 1. They are outlined with yellow or black dash lines and are labeled CUT HERE FOR EMERGENCY RESCUE or some other such directive.
678 - 2. You should cut the two sides and bottom, using the top as a hinge to swing the cut section outward and upward.
678 - 3. The panel cut out should swing outward so as not to obstruct movement from the interior to the ground.
678 - 4. Padding sharp openings.
678 - 5. By cutting the acrylic plastic along the edges of the frame. Cut three sides and lift off to break the uncut side.

679 - 1. To remove crewmembers from the aircraft in an emergency.
679 - 2. The extraction system, the module, and ejection seats.
679 - 3. Either by pulling the ejection handle or by "cocking off."
679 - 4. It is YOUR responsibility.

680 - 1. He is pulled from the aircraft by a rocket.
680 - 2. By a lanyard which is attached to the aircraft.
680 - 3. With the extraction system, the seat remains in the aircraft and the rocket motor is far enough away when it fires to keep from burning you.

681 - 1. The F-111.
681 - 2. A ballistic charge completely surrounds the module. When it is actuated, it sends scrap metal in all directions.
681 - 3. The aircraft may be at a full stop. No (zero) speed is necessary.
681 - 4. The catapult and the rocket-pack types.
681 - 5. The seat is "thrown" from the aircraft by the "telescope" effect of the catapult.
681 - 6. Its function is to fire the rocket pack.
681 - 7. He could be "cooked" or "roasted" when the rocket pack fires.

682 - 1. It is used as a seat belt, and often to attach the shoulder restraint straps to.
682 - 2. When the parachute is not a component part of the seat.
682 - 3. So you will have something to hold on to during extraction.
682 - 4. A harness worn by crewmembers when the parachute is a component part of the seat.
682 - 5. The Koch fitting and Rocket Jet fitting.

683 - 1. Through normal doors and hatches.
683 - 2. By a crewmember or passenger from inside the aircraft.
683 - 3. To prevent leg injuries to those persons.
683 - 4. They may be able to tell you the number and/or location of others still in the aircraft.
683 - 5. By using an axe or wedge tool around the frame or at the hinges.
683 - 6. By striking the panels at the corner farthest from the victims.
683 - 7. First use the flat side of the axe with comparatively light blows. If that doesn't do the job, increase the impact of the blows. Finally, if needed, use the pick end.
683 - 8. The configuration of the aircraft and wind, among other factors.
683 - 9. TO 00-105E-9.

684 - 1. To prevent them from "firing".
684 - 2. To pin the ejection handles, and, in some cases, the initiators.
684 - 3. The holes are hard to find in the dark or when foam has been used.
684 - 4. By disconnecting the "quick disconnects" or by cutting the initiator hose before it reaches the seat catapult.
684 - 5. The same way you do for a conventional seat, either by pinning or interrupting the firing sequence (cutting).
684 - 6. None. There are no hoses or lines to cut. You must pin the seat handles, both of them.

685 - 1. You can move the seat to a more advantageous position to effect crewmember removal.
685 - 2. The handle is located on the crewmember's right. When it is pulled, it releases the survival kit from the parachute harness.

685 - 3. The lap belt, leg and arm restraints, and shoulder restraint devices.
685 - 4. The inertia reel is a device attached to the shoulder restraint straps of a crewmember. It is designed to restrain or retract the crewmember in the spine-straightening position.

686 - 1. Three.
686 - 2. By way of the rescue path.
686 - 3. Two.
686 - 4. At any time the rescue team members inside the aircraft are out of sight of the team member outside the aircraft or out of sight of the rescue opening.
686 - 5. On the aircraft's rescue side.
686 - 6. The normal method.
686 - 7. A pry axe, the initiator hose cutter, and harness cutter.
686 - 8. The canopy should be blocked at fully open.
686 - 9. The one closest to the seat.
686 - 10. By installing safety pins, pulling the safety handle, opening the quick disconnects and/or cutting the indicator hose, depending upon the situation and type of escape system.
686 - 11. a. Five seconds.
  b. Master or battery switches.
  c. Master switch, then battery switch.
  d. To allow the fuel valves to rotate closed.
686 - 12. By grasping the shoulder straps or under his arms and jerking him from his seat.
686 - 13. The *prefire plans* will determine the procedures, and *practical training* will determine your speed and accuracy.

687 - 1. Without training in automobile rescue, you will accomplish nothing other than seriously injuring or perhaps even killing the victim.
687 - 2. The general rule that no injured victim be moved before he is given emergency first aid when his life or well-being are endangered where he is.
687 - 3. Five stages; (1) gaining access to the victim, (2) conducting the primary survey, (3) disentanglement, (4) preparation for removal, and (5) removal.
687 - 4. The threat of fire.
687 - 5. The location and position of the automobile, damage to the vehicle, and position of the victim in the vehicle.
687 - 6. Establishing and maintaining an airway, giving artificial ventilation, and controlling bleeding.
687 - 7. The removal of the victim from the vehicle.
687 - 8. Removing any restraining devices keeping a victim inside the vehicle, or removing the vehicle and/or parts from the victim.
687 - 9. Preparation for removal includes protecting the victim from further injury and facilitating removal. Removal involves taking the victim from the vehicle and into the ambulance.

688 - 1. Prying. Either manually or with powered equipment.
688 - 2. The metal safety lock which prevents prying the door open.
688 - 3. Lifting, pulling, or cutting the car away from the victim.
688 - 4. They should be removed through the top of the car. This may be accomplished by turning down the top of the car after cutting through the top itself, or by cutting the door post and turning down the top.
688 - 5. The air chisel.
688 - 6. Cutting the top of the car is slower and gives a smaller opening than does cutting the door post.
688 - 7. It is used to pull away doors, crushed corner posts, and/or jammed seats and dashboards.

689 - 1. By means of a spine board.
689 - 2. Anytime a victim is unconscious or complains of pain or discomfort, no matter how slight.
689 - 3. For the stabilization of victims in the sitting position.
689 - 4. The head is supported, and the neck is immobilized. The head is fastened in place by a head and chinstrap. The victim is them secured to the body portion of the board by two long straps applied across the chest and around the waist.
689 - 5. Ingenuity, common sense, and mechanical knowledge.

690 - 1. 1. Failure to recognize hazardous conditions or practices.
  2. Inability to get out of dangerous situations.
  3. Lack of knowledge of safe ways in which to aid or rescue drowning victims.
690 - 2. A reasonable swimming ability.
690 - 3. You must estimate the distance from the victim and depth of the water to determine how the rescue is to be made.
690 - 4. When it is evident that a swimmer is caught in a current, or one who is merely tired or panic stricken.
690 - 5. In a vertical position, head thrown back, and arms extended forward and upward.
690 - 6. To preserve your own life.

691 - 1. Your own survival.
691 - 2. The Civil Defense officials.
691 - 3. All of your knowledge and skill.
691 - 4. Safety and training.

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STOP-

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

57150 04 22

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

FIRST AID AND RESCUE

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (600) The speed with which asphyxiation takes place depends to a great extent upon the

   a. degree of airway obstruction.
   b. size of the victim's lungs.
   c. amount of blood loss.
   d. physical condition of the victim.

2. (600) There may be no automatic and involuntary reaction to airway blockage in the alcohol or drug user due to the depressed state of which of the following systems?

   a. Cardiovascular.
   b. Pulmonary.
   c. Circulatory.
   d. Nervous.

3. (601) If a patient has a blue or grey color in his eyelids, mucous membrane, or on the inner surface of the lips, it usually indicates that

   a. the patient is not getting enough oxygen.
   b. carbon monoxide has been inhaled.
   c. the patient is on drugs.
   d. the oxygen supply to the patient is too rich and must be reduced.

4. (602) If you use a pillow or rolled blanket to aid in opening an obstructed airway, you should place the pillow under the patient's

   a. shoulders.
   b. head.
   c. neck.
   d. back.

5. (602) Which one of the following can be considered the most important step in aiding a person who is suffering from asphyxiation?

   a. Clearing foreign matter from the air passage.
   b. Forcing air into the lungs.
   c. Lifting the jaw.
   d. Tilting the head.

6. (603) How many beats per minute does the normal adult's heart average?

   a. 60.
   b. 70.
   c. 80.
   d. 90.

7. (604) Even when the body is at rest, the blood is circulated throughout the body once every

   a. minute.
   b. 3 minutes.
   c. 4 to 6 minutes.
   d. 15 minutes.

8. (604) At times of maximum output, the heart can deliver up to how much blood per minute?

   a. 12 pints.
   b. 12 quarts.
   c. 44 pints.
   d. 15 gallons.

9. (605) How many major pressure points are located on each side of the body?

   a. 2.
   b. 4.
   c. 12.
   d. 24.

10. (606) A tourniquet should only be used

    a. during treatment of all snake bits.
    b. when hemorrhage cannot be controlled by other means.
    c. when you have trouble finding a pressure point.
    d. when the victim is in deep shock, bleeding, and not breathing well.

11. (607) Which of the following statements best describes "shock" when used as a medical term?

    a. Shock results when the blood vessels constrict to the extent that there is not enough blood to fill the system.
    b. Shock results from failure of the cardiovascular system to supply sufficient blood to all parts of the body.
    c. A strong willed person may ward off the effect of shock by exerting his will to control constriction of the vessels in the cardiovascular system.
    d. Shock is caused by excessive dialation of the cardiovascular system and results from too much oxygen in the blood.

12. (608) The type of shock not caused by impairment of circulation is

    a. cardiogenic shock.
    b. hemorrhagic shock.
    c. respiratory shock.
    d. psychogenic shock.

13. (608) Metabolic shock is caused by

    a. release of toxins into the blood stream.
    b. loss of control of the nervous system.
    c. inadequate functioning of the heart.
    d. loss of body fluids and changes in body chemistry.

14. (609) If there is any doubt as to the best position in which to place a victim when treating for shock, then the victim should be laid

    a. perfectly flat.
    b. with the lower extremities elevated.
    c. with the upper torso slightly elevated.
    d. so that the entire body is tilted down at the head.

15. (610) While some cells of the body may live for hours without oxygen, the cells of the brain die within what period of time when deprived of oxygen or blood?

    a. 45 seconds.
    b. 1 minute.
    c. 4 to 6 minutes.
    d. 10 to 12 minutes.

16. (611) When properly performed, cardiopulmonary resuscitation results are approximately what percent of that produced by a normally operating heart?

    a. 20.
    b. 35.
    c. 50.
    d. 75.

17. (612) When performing CPR, the compression should be made at a rate of

    a. 40 to 50 per minute.
    b. 50 to 65 per minute.
    c. 60 to 80 per minute.
    d. 80 to 100 per minute.

18. (612) The pulmonary phase of CPR should not be supplied by

    a. mouth-to-mouth means.
    b. mouth-to-nose techniques.
    c. a bag mask resuscitator.
    d. pressure-cycled resuscitators.

19. (613) When two persons are performing CPR, the patient is ventilated at what rate?

   a. One double sized breath after every 5 chest compressions.
   b. One double sized breath after every 10 chest compressions.
   c. Two regular sized breaths after every other chest compression.
   d. Two double sized breaths after every 15 chest compressions.

20. (614) During CPR compression, the ribs may be fractured and the lungs and heart lacerated if the hands are positioned too far

   a. up the chest.
   b. down the chest.
   c. to the left side of the chest.
   d. to the right side of the chest.

21. (614) During CPR, a change in pupil size and a freshening in the patient's skin color are both good indications that

   a. spontaneous respiration is about to return.
   b. oxygenated blood is being circulated.
   c. the patient has come around and will only need to be watched.
   d. definite treatment will not be required by a physician.

22. (615) Which of the following techniques for providing pulmonary resuscitation is superior to all others?

   a. Bag mask.
   b. Mouth-to-nose.
   c. Mouth-to-mouth.
   d. Mouth-to-airway.

23. (616) The first step in giving mouth-to-mouth resuscitation to a patient is to

   a. clear the mouth.
   b. tilt the head back.
   c. pinch the nose closed.
   d. ventilate the patient by blowing forcefully into the mouth.

24. (616) Mouth-to-mouth resuscitation breathing cycles for infants should be made at what rate per minute?

   a. 10 cycles.
   b. 12 cycles.
   c. 15 cycles.
   d. 20 cycles.

25. (617) Oropharyngeal airways are used

   a. as a replacement for a damaged stoma.
   b. to force the patient's head back to maintain an airway.
   c. to hold the base of the tongue forward so it does not block the air passage.
   d. to maintain an open airway when the mouth-to-nose technique of resuscitation must be used.

26. (618) When using the bag mask resuscitator, exhalation back into the bag is prevented by

   a. removing the bag from the mask.
   b. action of the valve in the mask.
   c. closing of the O_2 inlet nipple.
   d. a one-way inlet valve.

27. (619) When checking a victim for injuries, you should not pull on the belt or waistband of the person's clothing because

    a. the clothing may be torn as a result of the pulling.
    b. portions of the body may be exposed when not necessary.
    c. the weight of the victim may cause the belt or waistband to cut them.
    d. the victim may have spinal injuries.

28. (620) What will happen if a gauze roller bandage is applied too tightly?

    a. The compress to be held in place will slip off the wound.
    b. The circulation of the victim may be impeded.
    c. Blood clots will form in the arteries and cause cardiac arrest.
    d. Nothing, since the elastic properties of the bandage preclude its being applied too tightly.

29. (621) When a cravat bandage is used on the elbow, the tie should be made

    a. in the hollow of the elbow.
    b. on the point of the elbow.
    c. on the inside edge of the hollow.
    d. on the outside edge of the hollow.

30. (622) The most versatile and useful single bandage is considered to be the

    a. cravat.
    b. gauze roller.
    c. gauze square.
    d. triangular.

31. (622) When a triangular bandage is used as an arm sling, it should be adjusted so that the hand is in what position?

    a. Even with the elbow.
    b. Two to three inches below the level of the elbow.
    c. Two to three inches above the level of the elbow.
    d. On a line of sight from the patient's chin to the elbow.

32. (623) The type of wound usually not accompanied by severe bleeding is

    a. an avulsion.
    b. a puncture.
    c. an incision.
    d. a laceration.

33. (624) Which of the following is not a reason for removing an impaled object?

    a. It interferes with the victim's breathing.
    b. Bleeding cannot be controlled with the object in place.
    c. Transporting the victim is easier with the object removed.
    d. The impaled object is in position to lacerate the heart/lungs during necessary CPR.

34. (625) If tension pneumothorax develops after a chest wound has been sealed, you should

    a. start CPR at once.
    b. unplug the seal immediately.
    c. reseal the hole as the first seal is leaking.
    d. do nothing since the lung has "blown out."

35. (626) The type of fracture caused by a break that splits along the length of the bone is called

    a. an overriding fracture.
    b. a transverse fracture.
    c. an oblique fracture.
    d. a greenstick fracture.

36. (627) How long should a rigid splint be?

a. At least 12 inches.
b. At least 20 inches.
c. Not less than 14 inches nor more than 30 inches.
d. Long enough to be secured above and below the fracture site including joints.

37. (627) Which of the following is not a general symptom of a fracture?

a. Deformity of the part.
b. Moderate to severe swelling.
c. Pain in the area of the fracture.
d. A lengthening of the fractured limb.

38. (628) The symptoms of poisoning vary with the

a. amount of poison involved.
b. length of time between poisoning and treatment.
c. nature of the poison and the route of entry into the body.
d. age and physical condition of the victim.

39. (628) An individual reacting to poisoning with nausea, diarrhea, and vomiting has most likely been poisoned by

a. injestion.
b. inhalation.
c. absorption.
d. injection.

40. (629) To dilute an injested poison, large amounts of what should be given to the victim immediately?

a. Milk and/or water.
b. Tea or coffee.
c. Baking soda/powder.
d. Salt water/soft drinks.

41. (629) The most important step in treating a victim for absorbed poison is to

a. flush the affected area with water for at least 15 minutes.
b. apply medication to the affected area.
c. establish an airway and ventilate the victim.
d. remove the victim to a safe area and start CPR.

42. (630) Of the four kinds of poisonous snakes in the United States, the venom of which affects the nervous system?

a. Coral snake.
b. Rattlesnake.
c. Copperhead snake.
d. Cottonmouth snake.

43. (631) When administering first aid to a victim of severe burns, the first objective should be to

a. relieve the pain.
b. prevent infection.
c. treat for shock.
d. restore lost body fluid.

44. (632) Electrical burns are often more serious than they first appear because they often involve

a. the muscles.
b. the internal organs.
c. deep layers of the skin.
d. all of the above.

45. (633) The backstrap carry may be used when the victim is about the same size as the carrier and when the

    a. victim is unconscious and has a broken arm.
    b. victim is conscious and has severe burns on the chest.
    c. victim is unconscious and has no broken bones.
    d. carrier is using a self-contained breathing apparatus to "buddy-system" the victim from a toxic area.

46. (634) Prior to making the first lift during a fireman's carry, the carrier should be positioned

    a. kneeling at the victim's head looking down on the victim's face.
    b. standing straddle the victim looking down on the back of the victim's head.
    c. standing by the victim's right shoulder looking down at the victim's toes.
    d. kneeling at the victim's left side looking across the victim's midsection.

47. (635) When one carrier grasps a victim by the legs and the other grasps the victim under the arms and around the chest, they are using the

    a. seat carry.
    b. modified chair carry.
    c. carry by extremities.
    d. backstrap drag carry.

48. (636) How high is the victim lifted on the initial lift of the three-man hammock carry?

    a. Six to eight inches.
    b. To the carrier's knees.
    c. To the carrier's waist.
    d. To the carrier's chest.

49. (636) The number of persons required to effect the traction blanket lift is

    a. 2.
    b. 3.
    c. 4.
    d. 5.

50. (636) To effect the three-man hammock carry, the team members are positioned so that the team leader is

    a. on either side of the victim at the shoulders, #2 member on the same side as the leader at the victim's hips, and #3 member on the opposite side of the victim at the waist.
    b. at the victim's head facing the feet, #2 member on either side of the victim between the waist and hips, and #3 member at the victim's feet facing the team leader.
    c. at the victim's feet facing the victim's head, #2 member at the victim's left shoulder facing the team leader, and #3 member at the victim's other shoulder facing team member #2.
    d. at the victim's left hip facing forward, #2 member is at the victim's waist on the right side facing aft, and #3 is at the victim's left shoulder facing both other team members.

51. (637) Pads are not needed to fill the voids between the victim and the spine board when the victim is

    a. transported in the prone position.
    b. transported in the supine position.
    c. to be transported for only a very short distance.
    d. only suspected of having a spinal injury and medical assistance is 30 minutes or less away.

52. (638) Under which of the following conditions should the straddle slide be used?

   a. When you are short at least two of the number of persons needed to make a log roll lift.
   b. As an alternative to the log roll where space is limited such as in a narrow hallway or between immovable objects.
   c. Where the victim will only be slid a short distance to be put into position to effect a log roll lift.
   d. When the victim's injuries are such that a padded spine board may or may not be needed for immobilization of the injuries.

53. (639) When enough people are available, how many should be used to carry a victim on a stretcher?

   a. 2.
   b. 3.
   c. 4.
   d. 6.

54. (640) After initial training and from experience gained by exposure to emergencies, your future performance as a rescue team member will depend upon

   a. the number of persons you physically rescue.
   b. the number of hours of practical training you conduct and/or receive.
   c. the ability to learn new techniques and retain past knowledge for use in other emergency situations.
   d. a continual assignment to the rescue vehicle and sufficient incidents to perform realistic operations.

55. (641) As you complete your inspection of the air pack and return it to its case, you should unbuckle all harness straps except the

   a. waist strap.
   b. left side strap.
   c. right side strap.
   d. upper chest strap.

56. (642) Prior to putting the Scott air pack into operation, the air cylinder pressure gauge should be checked for full pressure which is

   a. 1,850 psi.
   b. 1,910 psi.
   c. 1,980 psi.
   d. 2,150 psi.

57. (642) The alarm on the MSA air pack will sound at

   a. 360 psi.
   b. 400 psi.
   c. 540 psi.
   d. 610 psi.

58. (643) Both the Scott and MSA air packs contain enough air, when full, to operate the face mask for approximately how many minutes?

   a. 15.
   b. 30.
   c. 45.
   d. 60.

59. (644) When filling a small air cylinder using the cascade method, the storage cylinder used first is the one

   a. with the highest pressure.
   b. nearest the cylinder being filled.
   c. with the lowest pressure that is above the pressure of the small cylinder.
   d. with the highest pressure that is below the pressure of the small cylinder.

60. (645) When handles are found to be loose in ball peen hammers, you should

a. replace the handle.
b. soak the head and handle in warm water to swell the handle.
c. drive larger wedges cross-ways of the original wedges.
d. taper drill the handle and drive in dowell rods.

61. (646) In addition to the adjustable combination pliers, the pliers most commonly used by fire protection personnel are

a. half-round nose and butt cutters.
b. round nose and side seam cutters.
c. box nose and pressure grip.
d. round nose and half-round nose.

62. (647) Crystallization occurs when which of the following comes in contact with the lens safety of the goggles?

a. Water and carbon dioxide.
b. Protein foam and AFFF.
c. Gasoline and oil.
d. Dry powder and foam.

63. (647) The safety pins carried on the rescue vehicle are used primarily to

a. make quick repairs to bunkers.
b. secure dressings used in first aid.
c. hold doors, windows, and/or hatches open.
d. prevent accidental firing of the escape system.

64. (648) The cable cutters have a rated insulation resistance of

a. 10,000 volts.
b. 12,000 volts.
c. 14,000 volts.
d. 16,000 volts.

65. (648) To cut flooring, using a pick-headed fire axe, the cuts should be made at an angle of about

a. 90°.
b. 60°.
c. 45°.
d. 30°.

66. (649) How many blades does the "V" blade knife have?

a. One blade for seat belts and one blade for harnesses.
b. One blade that will cut either seat belts or harnesses.
c. Two blades for seat belts and none for harnesses.
d. Two blades that will cut both seat belts and harnesses.

67. (650) The blade of the crash axe is prevented from passing completely through the metal skin of an aircraft by the

a. shape of the blade.
b. bevel of the blade.
c. stops on each side of the blade.
d. angle at which the blade contacts the metal.

68. (650) When using the crash axe, you may safely cut through electrical wire carrying up to

a. 20,000 volts.
b. 23,000 volts.
c. 27,000 volts.
d. 30,000 volts.

69. (651) What part of the door opener should be inserted into the staple of a door hasp to pry the staple out?

a. Tapered hook.
b. Hooked horn.
c. Knob.
d. Claw.

70. (651) Which one of the following features is not a design feature of the door opener?

a. A tapered hook.
b. The battering knob.
c. A square shank.
d. The claw.

71. (652) How many watts of power does a portable generator produce at 3,600 rpm?

a. 500.
b. 750.
c. 1,000.
d. 1,250.

72. (653) The oil to gasoline mixing ratio for the engine-driven blowers is

a. 1 to 2.
b. 1 to 4.
c. 1 to 8.
d. 1 to 10.

73. (654) The Hurst rescue tool provides how many pounds of usable, lifesaving force?

a. 8,000.
b. 9,000.
c. 10,000.
d. 11,000.

74. (655) When using the Porto-power tool on a vehicle accident, the best attachment for picking off the chrome window moldings is the

a. bail hook.
b. heavy-duty knife.
c. quality snips.
d. pry axe.

75. (655) The air chisel is powered by

a. a portable gasoline powered air compressor.
b. 100-pound CO_2 bottles filled with air.
c. a vehicle mounted air compressor.
d. compressed air tanks.

76. (656) Oil is mixed with gasoline for the K-12 saw engine at a ratio of

a. 1 to 5.
b. 1 to 10.
c. 1 to 15.
d. 1 to 25.

77. (657) What type of gasoline should be used in the Target saw engine?

a. Regular grade, low lead content.
b. Regular grade, high lead content.
c. High test, no lead content.
d. High test, low lead content.

78. (657) What, if anything, will happen to the engine on a target saw if the fuel is mixed at a ratio of 1/4 pint of SAE 40 two-cycle motor oil to one gallon of gasoline?

a. Nothing.
b. The engine will overheat.
c. The spark plug will foul.
d. The combustion chamber will build lead deposits.

79. (658) The blades for the electric power saw come in which of the following sizes?

a. 4 and 8 inches.
b. 6 and 8 inches.
c. 8 and 10 inches.
d. 12 and 14 inches.

80. (659) The correct sequence to be used when forcible entry is required is

a. doors, walls, windows, and roofs.
b. windows, walls, roofs, and doors.
c. roofs, doors, walls, and windows.
d. windows, doors, roofs, and walls.

81. (660) Ledge doors are normaly found on

a. offices and family quarters.
b. warehouses and storerooms.
c. hospitals and confinement facilities.
d. alert shelters and hangars.

82. (660) The method of gaining entry through a door is determined by the

a. manner in which it is hung and type of jamb.
b. construction of the door and the way it is hinged.
c. manner in which it is hung and how it is locked.
d. way the door swings and the installation of the hinges.

83. (661) Sliding patio doors are forced open by inserting a

a. wedge tool between the door and jamb near the lock and prying away from the frame.
b. wedge tool between the door and track at the bottom and prying up and in the frame.
c. pointed tool between the door and frame at the wall and prying away from the jamb.
d. pointed tool between the glass and frame at the lock and prying toward the frame.

84. (662) When forcing a door that opens toward you, in which direction do you pry on the tool bar to move the door and jamb apart?

a. Toward the center of the door.
b. Away from the center of the door.
c. Toward the top of the door.
d. Away from the top of the door.

85. (663) When forcing a door in a stopped frame that opens away from you, where should you insert the tool blade to remove the stop?

a. At the lock.
b. Halfway between the hinges on the hinged side.
c. Upper corner opposite the hinged side.
d. Lower corner opposite the hinged side.

86. (664) When determining how to force a metal swinging door, the second factor to be taken into consideration is

a. how the door is locked.
b. how the door is hung.
c. how the door is constructed.
d. the type of jamb the door is set in.

87. (665) Which of the following instruments would be more effective for breaking tempered glass door panels?

a. A blunt object of unhardened steel.
b. A sharp-pointed object of unhardened steel
c. A blunt object of hardened steel.
d. A sharp-pointed object of hardened steel.

88. (666) Which of the following types of overhead doors present the most resistance to being forced?

a. Slab.
b. Folding.
c. Rolling.
d. Sliding.

89. (637) When a window has been opened with a minimum amount of force but the frame is still damaged beyond repair, the frame is most likely made of

a. wood.
b. aluminum.
c. hardened steel.
d. unhardened steel.

90. (668) A casement-type window is forced by

a. breaking the uppermost pane of glass, unlocking the lock, and pushing in on the top of the frame.
b. breaking the lower left corner pane and reaching in and pulling out and down on the operating lever.
c. breaking the lowest pane of glass, forcing or cutting the screen in the same area, and reaching inside unlocking the latch and operating the crank at the bottom.
d. inserting a wedge tool in the center of the frame and prying down until enough space is made to allow the second wedge tool to be inserted which is pryed up until the latch gives.

91. (669) A wooden checkrail window where the latch is in the center of the checkrail may be forced open by inserting a wedge tool

a. at the top of the window above the latch and prying down until the latch gives.
b. between the checkrails and prying out until the latch screws give.
c. between the frame and checkrail and prying out until the latch halves separate.
d. at the center of the lower sash and prying up until the screws pull out and the sashes separate.

92. (670) "Projected In" factory window is usually hinged at the

a. top and swings inward at the bottom.
b. side and swings inward at the opening.
c. bottom and swings inward at the top.
d. center and swings in at the bottom and out at the top.

93. (671) A forced opening of a jalousie-type window should be avoided because of the

a. cost of replacement.
b. time required to force.
c. type of glass used.
d. height at which they are installed.

94. (672) Window openings covered with heavy wire mesh should be avoided since the

a. heavy wire mesh cannot be cut.
b. mesh is interconnected to an alarm system in most cases.
c. cut mesh presents a very serious hazard to personnel or equipment passing through.
d. forcing of the wire mesh guards involves considerable time.

95. (672) To free bars set in masonry that cover a window, you should strike the bar with a sledge hammer

    a. in the center.
    b. about 10 inches from the sill.
    c. at the point where the bar bends.
    d. at the base where the bar contacts the wall.

96. (673) The initial or primary search for victims will be conducted by the

    a. assistant fire chief.
    b. first crew to arrive.
    c. rescue team members.
    d. crossman pumper crew.

97. (673) When making a search of a building, you should remain on your hands and knees

    a. because it is easier to breath near the floor.
    b. because there is less smoke and you can see farther.
    c. to keep from falling through unknown openings.
    d. so you won't hit your head on unseen obstructions.

98. (673) If the building to be searched is on fire, the search for victims should begin

    a. at the lowest level of the building.
    b. at the highest level of the building.
    c. on the floor above the fire.
    d. on the fire floor.

99. (674) When making a secondary search of a standing, badly damaged building, the rescuers should work

    a. as individuals.
    b. in pairs.
    c. in teams of three.
    d. in teams of four.

100. (674) Individuals or teams should be assigned to make a secondary search for victims as soon as

    a. conditions permit.
    b. the fire is under control.
    c. the last pumper arrives.
    d. the primary search is completed.

101. (674) The method chosen, techniques used, and time required to reach a victim need to be determined by the

    a. senior fire officer.
    b. number of searchers.
    c. extent of injuries to the victim.
    d. type of incident and situation involved.

102. (675) The crew members that would normally be required to move forward into emergency crew positions are the

    a. instructor pilots.
    b. boom operators.
    c. copilots.
    d. radar operators.

103. (676) Before any canopy can be opened manually, its

    a. pneumatic system must be drained.
    b. hydraulic pressure must be relieved.
    c. glass must be cracked.
    d. locking mechanism must be unlocked.

104. (677) Aircraft that have escape hatches located over the wings are

a. large frame aircraft of the C-5 type.
b. small frame aircraft of the F-106 type.
c. small frame aircraft of the C-7 type.
d. large frame aircraft of the KC-135 type.

105. (678) What presents the most difficult problem in making an aircraft forcible entry?

a. Gaining entry through the fuselage.
b. Removal of emergency escape hatches.
c. Jettisoning a locked canopy.
d. The location of the crew and passengers.

106. (679) During rescue operations, the only way an escape system may be actuated is by

a. improper systems shut down.
b. pulling the ejection handle or by "cooking off."
c. inadvertent movement of crash damaged parts/components.
d. failure of the rescue team members to install ail safety pins in the seat.

107. (680) The safest escape system from a firefighter's point of view is the

a. extraction system.
b. module ejection system.
c. catapult ejection seat.
d. rocket-pack ejection seat.

108. (681) The module ejection system is used on what aircraft?

a. All fighters.
b. The F-111 only.
c. Slow moving aircraft.
d. High winged aircraft and helicopters.

109. (682) The standard military parachute harness may be removed by releasing how many ejector fittings?

a. 2.
b. 3.
c. 4.
d. 5.

110. (683) On most aircraft, the windows designed to be used as emergency exits are identified and have

a. an outline in red around each window.
b. a yellow and black dashed line around the glass.
c. a yellow arrow with black "RESCUE" pointing to each window.
d. latch releases on both the inside and outside of the cabin.

111. (684) The only way to safety the module ejection system is by

a. cutting the lines or hoses.
b. pulling the safety handles.
c. pinning both seat handles.
d. disconnecting the quick disconnects.

112. (685) Ejection seats equipped with a survival kit will always have a survival kit release which is the

a. yellow and black handle on the crewmember's left.
b. solid yellow handle on the crewmember's right.
c. yellow and black handle on the crewmember's right.
d. solid yellow handle on the crewmember's left.

113. (686) How many rescue team members should make the initial entry into an aircraft?

a. 1.
b. 2.
c. 3.
d. all.

114. (686) Which of the following is the proper procedure for cockpit shutdown?

a. Shut down fuel switch, wait at least 5 seconds, then shut down master switch and battery switch.
b. Shut down master switch and fuel switch, wait 5 seconds, and shut down the battery switch.
c. Shut down fuel, battery, and master switches in that order with no delay.
d. No set sequency is required as long as all are shut down.

115. (687) The primary survey of automobile accidents may include all the following emergency procedures except

a. controlling the bleeding.
b. giving artificial ventilation.
c. giving cardiopulmonary resuscitation.
d. establishing and maintaining an airway.

116. (688) Generally, what is the best cutting tool for use in automobile rescue?

a. A pry axe.
b. The K-12 saw.
c. The PTO wench.
d. The air chisel.

117. (689) A spine board is used

a. only when a victim is unconscious.
b. only when the victim complains of pain or discomfort.
c. before any accident victim is moved.
d. any time a victim complains of pain or discomfort or is unconscious.

118. (690) In which of the following swimming rescue situations should you not take a slightly longer time in going to an individual's rescue than you would in other cases?

a. The victim is panic-stricken.
b. The victim is merely tired.
c. It is evident the victim is caught in a current.
d. The victim is alternately sinking and reappearing on the surface.

119. (691) In the event of a natural disaster, your first concern should be to

a. survive yourself.
b. help others to survive.
c. restore the base to operation.
d. make sure all rescue business is taken care of.

120. (691) Which of the following items are considered to be the most important in the business of rescue?

a. Safety and training.
b. Equipment and tools.
c. Personnel assignments and vehicles assigned.
d. Time allowed to perform and location of rescue to be made.

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CDC 57150

FIRE PROTECTION SPECIALIST

(AFSC 57150)

Volume 5

Fire Protection Vehicles

Extension Course Institute

Air University

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

THIS COURSE is beginning to get a little long by now but stick with it and you can successfully complete it. The past volumes have presented you with lots of varied information. Now, we will begin to get into some information that will be used in day-to-day work in the fire station.

In this volume, we will cover many aspects of vehicle operation and inspection that you can expect to perform as a driver/operator of a firefighting and rescue vehicle. We will cover such areas as driving; vehicle inspection and inspection forms; Structural Pumper Operation; crash, fire, and rescue vehicle operation; and support vehicles.

Code numbers appearing on figures are for preparing agency identification only.

Please note that in this volume we are using the singular pronoun he, his, or him in its generic sense, not its masculine sense. The word to which it refers is person.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTGOX, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If they can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 24 hours (8 points).

Material in this volume is technically accurate, adequate, and current as of July 1979.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Driving

BEFORE WE HAD motorized fire apparatus, there were very few problems in manning the apparatus with qualified personnel. Let's look back and see. The bucket brigade didn't need a driver/pump operator, did it? The hand-drawn, hand-operated pumper did put some pressure to the water, but the person in charge in those days would be more closely associated with the coxswain of a rowing scull today. Traffic conditions and laws, mechanical malfunctions, and other difficulties were practically nonexistent. Next came the horse-drawn, stream-driven fire engine that did require an experienced driver/operator. Traffic and mechanical problems increased; however, a bale of hay, a bucket of water, and a shovelful of coal took care of most of the needs. Then came the gasoline engine and its adaptation to transportation. One use for this engine was to completely mechanize fire apparatus for mobility as well as for driving the pump.

Since the time the first one was mechanized, vehicles have become more efficient and also more numerous. Traffic has increased and the laws to control this increased traffic have also become more numerous. With these conditions increasing all the time, the training period for driver/operators has lengthened and the amount of knowledge needed to be a good driver has multiplied.

This chapter is designed to help you be an expert driver by recalling to you what a vehicle driver should know. The following paragraphs have been written for you as a military driver of Government-owned wheeled vehicles. These instructions will aid you in reaching a high degree of driving knowledge, thereby helping to assure the safety of yourself and others. These paragraphs are applicable to all vehicles in general and are a guide for everyday driving situations and driving under difficult situations. Local rules will take precedence over any instruction which appears in the following.

800. Define "official use" of Government vehicles; list qualities required of professional drivers; and state practices of general driving, starting, and fuel conservation.

General Driving. Government vehicles are for official uses only. Official use is defined as the employment or authorization of employment of such Government vehicles, loaned, leased, or rented for the discharge of performance of an official duty, function, or service. In other words, any vehicle used by the Air Force in the performance of its duties is an official vehicle used for official purposes. You can easily violate this law by using a Government vehicle for some personal reason. An example of a violation would be for you to drive a Government vehicle to the commissary to pick up the groceries for your family.

You are to be a professional driver. Your military license will prove you are a professional. Therefore, you must possess physical, mental, and emotional stability; adequate information about your vehicle and traffic laws; sound knowledge of driving techniques; sufficient experience to form habits and to be a safe and skillful driver; and the proper attitude of responsibility, sportsmanship, and courtesy. Not only must you have the above qualities but also you must strive to perfect them to remain a professional, to stay in good physical condition, and to improve your knowledge of vehicles. You must try to improve your driving skills and techniques with each day's operation. As a driver, you are responsible for the safe operation of your vehicle, the care and cleaning of your vehicle and its equipment at all times, the safety and comfort of your passengers (this includes fastened safety belts), the security of vehicles and cargo entrusted to you, and the exercise of common sense. It is always a good policy to check the vehicle technical order or manufacturer's instructions before attempting to operate any unfamiliar vehicle.

Starting the Engine. On entering the driver's seat, first make sure the parking brake is set and the transmission shift lever is in the neutral or park position. If the vehicle is equipped with special power attachments, be sure that all power-control levers are in neutral. Depress the clutch pedal to release the load of the transmission and turn on the ignition key or switch. Pull the choke control out part way, depending on weather conditions. This will probably put the trottle at a fast idle position. If it does not, pull out the hand trottle or depress the accelerator pedal just enough to operate the engine slightly above the normal idling speed. During warm weather, or whenever the engine is warm, it is not generally necessary to use the choke or throttle. In extremely cold weather, the choke control should be pulled out all the way. (NOTE: Some vehicles are equipped with an automatic choke which can be set by depressing the accelerator to the floor and releasing it before attempting to start the engine.)

If the engine does not start within a very few seconds, release the starter switch and check whether you have performed the above operations correctly. As you become familiar with a given engine, you will learn the correct amount of throttle and choke so that the engine will start immediately. (NOTE: Certain manuals state 15 seconds as a maximum time for a "first try." If this time limit is exceeded, the battery and starting motor may be damaged. If the starter has been engaged without results, wait at least 30 seconds, then try it again. Notify your supervisor if the engine fails to start after several attempts.)

As soon as the engine starts, push in the choke control part way and adjust the trottle for a smooth idle. Use the choke only as much and as long as it is necessary to start and warm a cold engine. Do not race a cold engine. It takes time for the oil to circulate to all parts. If the engine is raced while cold, the lack of lubrication may cause serious damage to the pistons, bearings, and cylinder walls. Racing the engine also wastes fuel.

Note the oil gauge and ammeter reading. The ammeter should show some charge unless the engine is idling slowly, and the oil gauge should show some pressure. In vehicles equipped with oil and generator lights, the lights should go out immediately after the engine is started. If the gauges do not show the proper indications or the lights do not go out immediately after the engine has started, stop the engine immediately and notify your supervisor.

Conserving Fuel. Do not idle the engine of a parked vehicle except when necessary to keep the engine warm in extremely cold weather. Never permit the vehicle engine to idle for long periods of time. In addition to wasting fuel, excess idling causes carbon formation and oil dilution to take place in your engine. Never run the engine for the purpose of recharging a run-down battery unless specifically instructed to do so by your immediate supervisor. Never leave your vehicle unattended with the engine running. Do not exceed the allowable speeds indicated on the vehicle instruction plate (if applicable) or operate the vehicle at an engine speed so slow as to cause the engine to labor (pound). Vehicle instruction plates are usually located on the instrument panel.

Exercises (800):

1. What is the definition of "official use" as pertaining to Government vehicles?
2. If you are to be a professional driver, what qualities must you possess?
3. Before operating an unfamiliar vehicle, what is a good policy to follow?
4. Before starting the engine of any vehicle, what should you first check?
5. In cold weather, what position should the choke be in?
6. If the starter has been engaged without results, how long should you wait before attempting again?
7. Why should you not race a cold vehicle's engine?
8. Besides wasting fuel, what other ill effects does excess idling have on an engine?

801. For stated instances, give the principles of driving a vehicle equipped with a manual transmission.

Driving Vehicles with Manual Transmissions. Your clutch provides the means of applying the engine power to the wheels smoothly and gradually. Learn just where the clutch actually starts to engage. See how far the pedal moves to fully engage the clutch. Also see how much free play there is in the pedal and check how fast you should engage the clutch.

Clutch. Keep your foot off the clutch pedal except when actually starting, stopping, or shifting gears. Even a slight constant pressure on the clutch pedal causes excessive wear. For the same reason, when stopped on a hill, never slip your clutch to prevent your vehicle from rolling back; instead, use your brakes. A good driver will move the transmission shift lever into neutral while waiting for a long traffic light or when halted for other reasons. When slowing a Government vehicle to stop or turn a curve, reduce speed to 15 miles or less before depressing the clutch pedal. Coasting a vehicle at a high rate of speed with the clutch pedal depressed may damage the clutch or gears, and will be considered as vehicle abuse.

Manual shifting. Skill in manual shifting is a requirement of a good driver. Poor manual shifting can cause poor vehicle performance and vehicle damage. Know the gearshift lever positions. You should know them so well that you can shift to any gear without looking at the shift lever. The gear shift pattern is usually diagrammed on the vehicle caution plate. Do not move the gearshift lever from one position to another with the engine running until you have fully depressed the clutch pedal with your left foot. To shift gears smoothly and quietly, keep the pedal fully down until the shift has been completed.

After you have started and warmed the engine with the transmission in neutral and after you have acquainted yourself with the vehicle instruments and controls, you are ready to get actual driving operations under way. You should always start the vehicle moving in low or first gear, following these steps:

- Depress the clutch pedal and shift into low gear.
- Check the inside and outside rearview mirrors.
- Check "blind spots" and give signal.
- Let clutch pedal up slowly, pausing at the "friction point" or when you feel it taking hold. Hesitate, then check mirrors again for traffic.
- Release parking brake.
- Slowly release clutch pedal and at the same time slightly depress the accelerator.
- When driving operation is underway, remove your left foot from the clutch pedal completely.

Good driving practice on trucks (1½ ton or larger) often requires "double clutching" to permit proper engagement of the gears and to prevent loss of momentum. To shift to a lower gear by double clutching you must:

- Release pressure from accelerator as you begin depressing clutch pedal.
- When clutch pedal is fully depressed, move gear shift lever to neutral position.
- Release clutch pedal and at the same time depress accelerator to speed up the engine, clutch, and engine-driven gears in the transmission.
- Depress clutch pedal and let up on accelerator.
- While clutch pedal is depressed and before the engine-driven gears have slowed; move gear shift lever to next lower gear speed.
- Release clutch pedal and at the same time depress the accelerator to maintain the speed of the engine as the load is again connected to it by the engagement of the clutch. The procedure is the same for shifting to a higher gear speed, except that the engine is not accelerated while the gears are in neutral as this slows the engine-driven gears in the transmission.

When shifting gears in rough terrain and hills, you should not let your vehicle slow down to a point where the engine begins to labor or jerk before shifting into a lower gear ratio. Always anticipate the need for extra power and shift gears accordingly. When descending a hill, with or without a heavy cargo, drive with your vehicle in gear and the clutch pedal out. If the hill is steep enough to require the use of brakes to reduce speed, shift into the next lower gear at the crest of the hill and use the engine compression as a brake. This is very important on long grades. Extreme care should be taken to prevent excessive engine speed while descending a hill. Judge the necessary gear and shift, if necessary, at the crest of the hill *before speed has increased from downhill movement.* Ordinarily, the gear required to go up a hill is proper to use to go down the same hill. *Gearing down after vehicle speed has increased will throw the entire load against the engine, possibly causing extensive damage.* Except when used in the case of brake failure, damage resulting from this practice will be considered as vehicle abuse. With proper gear selection, intermittent application of brakes will keep the speed of the vehicle within safe limits.

When preparing to stop the vehicle, remove your foot from the accelerator and use the engine compression as a brake to assist in bringing the vehicle to a stop. Do not depress the clutch pedal until the motor is operating at low speed and is no longer serving as a brake, then depress the clutch pedal before the engine begins to labor from slow speed. The foot brake should be applied to assist in this braking action. When preparing to make a turn or stop, avoid downshifting at speeds above 20 miles per hour.

Exercises (801):

1. What position will a good driver put his transmission in while halted for a long period of time?

2. At what speed should your vehicle be prior to depressing the clutch?

3. To shift smoothly, the clutch pedal should remain in what position until shift is completed?

4. What gear should the driver use to start the forward motion of the vehicle?

5. When descending a steep grade, your transmission should be in a (low, high) gear.

6. What type braking should be used on long downhill grades?

7. When preparing to make a turn or stop, you should avoid making a downshift above what speed?

802. Cite proper driving positions and practices.

Driving Position and Practices. You should sit in an erect, comfortable position with your shoulders parallel with the back of the driver's seat. Adjust your seat as necessary to insure that you have a clear view to the front, and fasten your seat belt. Adjust the side and rear mirrors so that they give unobstructed views.

Place your right and left hand on opposite sides of the steering wheel at "10 and 2" or "10 and 4" clock position, as shown in figure 1-1. Hold the rim—not the spokes. Keep a firm but comfortable grip. Remove your hands from the wheel only when signaling, adjusting controls, or performing other acts of driving. (Position of the hands on the wheel is of prime importance for purposes of control, particularly in case of an emergency. You should be ready for a complete, controlled turn of the wheel in a fraction of a second at all times.)

Before putting the car into motion, carefully check traffic conditions. Also check the rear and front of the vehicle where children or objects could be located and would be difficult to see. Continually glance far ahead and be ready for possible errors or unsafe maneuvers by other drivers. Be aware at all times of conditions behind your vehicle by regularly glancing at rearview mirrors. Anticipation and good judgment can prevent a large percent of emergency situations.

Starting. You have already read instructions on starting vehicles; however, the following points are given on specific starting conditions. When you have to start on an upgrade, use your handbrake. Keep the handbrake on while you shift into low gear and begin to release the clutch pedal slowly. When the vehicle begins to pull against the brake, release the brake slowly. In this way, you can start without danger of rolling back and losing control of your vehicle. It may not be necessary to use the handbrake in vehicles equipped with automatic transmissions or special devices which prevent the vehicle from rolling back on hills. If you have to start on a slippery surface, such as ice or loose dirt, use second or high gear instead of low gear. Feed gas lightly and release the clutch pedal very slowly to avoid spinning the rear wheels.

Steering and turning. The safe and proper position of the hands on the steering wheel is, as shown in figure 1-1, on either side of the wheel a little above the center, or the right hand can be positioned a little below the center. Two hands are necessary for beginners and experienced drivers too. Your grip on the wheel should be firm but not tight. When you round a corner or make any other sharp turn, use the hand-over-hand method of steering. If you are turning to the right, begin by placing your right hand near the top of the wheel and pull the wheel down to the right. As the right hand nears the bottom of the circle, let the left hand take over, starting at a position on the left of the wheel, a little below the top. As the left hand nears the bottom of the circle, again place the right hand at the top of the wheel to continue the turn, if necessary. As you complete the turn and release pressure on the steering wheel, it will slide through your hands as the front wheels tend to return to their normal straightforward position. At low speeds and on some old vehicles, the wheels must be brought back to their normal position by reversing the direction of steering. Do not turn sharply to change lanes. Light pressure on the steering wheel will allow you to drift gradually from one lane to the other. Before you change lanes, remember to look for traffic that may be coming up behind you and to give a turn signal.

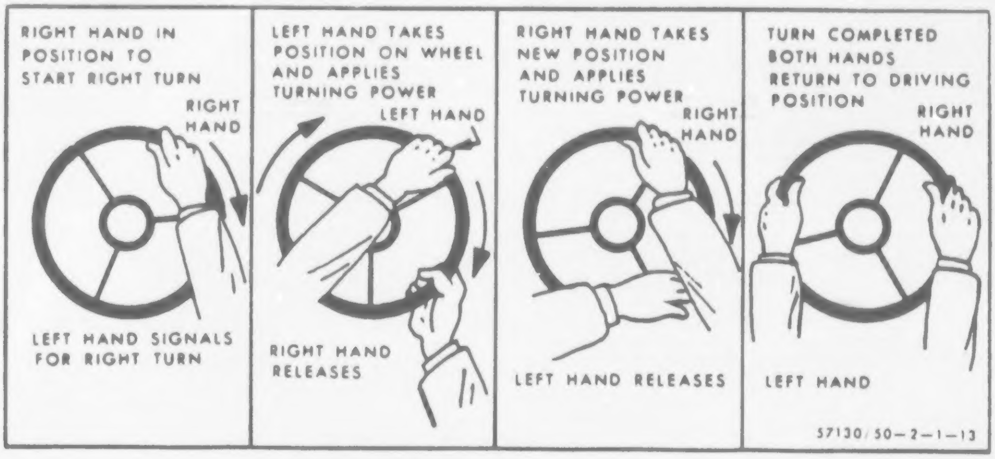
RIGHT HAND IN POSITION TO START RIGHT TURN
RIGHT HAND
LEFT HAND SIGNALS FOR RIGHT TURN
LEFT HAND TAKES POSITION ON WHEEL AND APPLIES TURNING POWER
LEFT HAND
RIGHT HAND RELEASES
RIGHT HAND TAKES NEW POSITION AND APPLIES TURNING POWER
RIGHT HAND
LEFT HAND RELEASES
TURN COMPLETED BOTH HANDS RETURN TO DRIVING POSITION
RIGHT HAND
LEFT HAND
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Figure 1-1. Steering and turning.

Exercises (802):

1. During normal driving operations, what posture should be maintained?

2. Your hands should be placed in what position on the steering wheel?

3. When is removing your hands from the steering wheel permissible?

4. When starting on an upgrade, should the handbrake on vehicles equipped with a manual transmission be released immediately? Why?

5. When starting out on slippery surface, what is the recommended gear to use?

6. When rounding a corner or making a sharp turn, what method of steering should be used?

803. Cite recommended procedures for safety braking and stopping.

Braking and Stopping. The proper use of brakes is one of the most important elements of good driving and one of the best indicators of driving capability. Your brakes are used to some extent in all stopping procedures, but they are seldom used alone. The emergency stop is an exceptional event for professional drivers, but they are always prepared for one. Except in emergencies, you will be a better and safer driver if you stop slowly and smoothly. To stop from high gear, remove your foot from the accelerator and depress the brake pedal. When the vehicle is almost to a stop, depress the clutch pedal to avoid stalling the engine. When you use this method, your engine acts as an additional brake while you are stopping. You can get even more braking effort from your engine if you remove your foot from the accelerator well before you apply the brakes. However, if you drive a vehicle with an automatic transmission or overdrive, you may get little or no braking effect from your engine. You must rely mainly on your brakes. Regardless of the type of transmission, the slow, smooth stop saves gas, tires, and brakes. By staying alert, the good driver can avoid sudden stops.

When you stop from low, second, or reverse gear, depress the clutch before you lift your foot from the accelerator. Stopping quickly from high speed may cause your vehicle to skid if your brakes are not properly applied. If you must stop quickly, fully apply your brakes, then release them at the instant they lock and immediately reapply them as necessary. If you "pump" the pedal, your tires have better traction as the vehicle slows down. Brakes have the greatest stopping power at the point just before the wheels lock.

Exercises (803):

1. When is the only time braking is not done slowly?

2. How can drivers avoid sudden stops?

3. When stopping from low, second or reverse gear, what should be done before applying the brake?

4. At what point do your brakes have the greatest stopping power?

804. State the dangers of excess speed and their effects on stopping distances.

Speed. No one thing accounts for more highway deaths than speed. You can be sure of this; your vehicle can go much faster than you can possibly drive it safely. Year after year the manufacturers increase the horsepower of their vehicles. Increased horsepower means better pickup and performance. It also means that vehicles can be driven easily at speeds much higher than roads, tires, or drivers are made for.

There are two reasons why speed is dangerous: (1) Each added mile per hour reduces the driver's ability to make the vehicle do what he wants it to do. (2) Each added mile per hour substantially increases the likelihood that an accident will result in death or serious injury. In a moment of danger, a driver going at high speed may have no more control over his vehicle than a hunter has over a bullet after it leaves the gun. The two most important things a driver can do to avoid a collision are to turn aside or stop. Let's see what happens to a driver's ability to turn aside or stop as speed increases.

Stopping Distances. At 20 miles an hour, a car with brakes meeting the legal requirements can be brought to a stop on a hard, dry, level surface 25 feet from the point at which the brakes actually take hold. At 40 miles an hour, it takes 100 feet; at 60 miles an hour, 225 feet; and at 80 miles an hour, 400 feet. The braking distance at 40 miles an hour is not twice the distance required at 20 miles an hour, but four times. The braking distance at 80 miles an hour is not 4 times the distance required at 20 miles an hour, but 16 times.

The figures given in the paragraph above are for the distances it takes to stop after the brakes are applied, but it takes longer to stop from the point at which danger is first recognized. There is always a moment, called reaction time, during which the driver is making up his mind to stop and getting his foot on the brake pedal. The figures assume the use of brakes meeting the legal requirements and a braking reaction time of three-fourths of a second, which is the reaction time for the average driver. When reaction time is included, the total stopping distance is considerably longer than the braking distance. For example: The braking distance for a stop from 60 miles an hour is 225 feet; but the stopping distance including an average reaction time is 291 feet.

Many times you can avoid a collision by merely slowing down. Suppose your speed is 40 miles an hour and you must slow down to 20 miles an hour. How far will you travel in slowing down? The braking distance at 40 miles an hour is 100 feet. At 20 miles an hour, it is 25 feet. By subtraction, you get the braking distance required for slowing down from 40 to 20 miles an hour: 75 feet. A reaction time of three-fourths of a second adds another 44 feet. Therefore, the total distance required for slowing down from 40 to 20 miles an hour is 119 feet. Suppose that you must slow down from 60 miles an hour to 40 miles an hour. The braking distance for a stop from 60 miles an hour is 225 feet; for a stop from 40 miles an hour, 100 feet; and the difference is 125 feet. Adding another 66 feet for a reaction time of three-fourths of a second, the total distance required for slowing down from 60 to 40 miles an hour is 191 feet. In both examples, it is necessary to slow down by 20 miles an hour to avoid a collision. Yet, slowing down from 60 to 40 miles an hour requires 72 more feet, or 60 percent more distance, than slowing down from 40 to 20 miles an hour. If you don't drive slowly enough, you won't be able to slow down soon enough. Play the percentages and live.

Even after it is too late to stop or slow down, a driver can often avoid a collision by swerving to one side. However, a speeding vehicle cannot be turned sharply without the risk of turning over. The faster a vehicle is going, the more distance it takes to turn safely from a straight path. Suppose that you must swerve a vehicle, with average turning ability, 3 feet to one side in order to avoid a pedestrian. How far away will you have to be when you first recognize the danger to miss the pedestrian without turning your vehicle over? It depends on the speed. At 20 miles an hour, you will need 32 feet; at 40 miles an hour, 66 feet; at 60 miles an hour, 94 feet; and at 80 miles an hour, 130 feet. Suppose you see another vehicle coming directly toward you on the wrong side of the road. The driver of the other vehicle is talking to a passenger and doesn't hear your horn. You can miss them if you can swerve 6 feet. How far away, when you first see the danger, do you have to be in order to swerve 6 feet? Again, it depends on your speed. If both vehicles are traveling at 50 miles an hour, you will have to be 198 feet away to be able to swerve 6 feet safely and soon enough to avoid a collision. If the speed of both vehicles is 60 miles an hour, you will have to be 232 feet away.

Speed is a killer. Speed not only makes accidents more likely; it makes death in accidents more likely. If you hit a stone wall at 20 miles an hour, the amount of damage done is the same as if your vehicle fell from the top of a building one story high. If you hit the wall at 40 miles an hour, the force of impact is about the same as if your vehicle fell from the top of a building four stories high; at 60 miles an hour, from a building nine stories high; at 80 miles an hour, from a building 16 stories high. If, at 60 miles an hour, you have a head-on collision with another vehicle at the same speed, the force of impact will be equal to about 1,000,000 pounds.

Exercises (804):

1. What driving factor causes more driving deaths per year than any other?

2. Give two (2) reasons why speed is dangerous.

3. What two factors must be taken into consideration when determining stopping distances?

4. What risk does the driver of a speeding vehicle take when he turns sharply?

805. State basic procedures for backing and making various types of turn arounds.

Backing. To back, steer with your left hand. Put your right arm on the back of the front seat (if the type vehicle permits), and turn your head over your right shoulder so that you can see out of the rear window. To turn when you are backing, turn the steering wheel in the same direction as you would if you were going forward. To back to the right, turn the wheel to the right. To back to the left, turn the wheel to the left. Some special-purpose vehicles, such as your firefighting equipment, can be backed only by using sideview mirrors. Drivers of these vehicles require special training in the art of backing. The driver usually sits erect in his seat so that he can see the sides of the vehicle and the area to the rear through each sideview mirror. Back slowly! In a vehicle with standard gears, you cannot control your speed safely while backing unless you use your clutch as well as your accelerator. Always come to a full stop before shifting into forward gear. Keep looking back until you are stopped. If you shift your eyes to the front as soon as you are ready to stop, you will be backing blindly for several feet. When backing in very close quarters such as a driveway or when visibility through the rear window is poor, you may find it necessary to use your right hand on the steering wheel while you look out the left window to see where you are going. In such a situation, you should post a guide, if available. *Never open either door while your vehicle is in motion.* At best, backing is more dangerous than going forward. You cannot see as well and your vehicle is harder to control. Before you back, even a short distance, make sure that there are no children around. Many a youngster has been crushed under the wheels of the family car while playing in his own backyard or driveway. Never back long distances unless absolutely necessary. It is much safer, and sometimes quicker, to turn around and cover the distance by going forward.

Turning Around. If you turn around on a street or highway, you want to be able to do it as quickly and safely as possible. If the road is wide enough and you have a good view in both directions, the U-turn is safe and quick. Pull as far to the right as you can, using the road shoulder if there is one, and come to a complete stop. Wait until there is no near traffic approaching from either direction and give a left-turn signal before making the turn. Make the turn slowly. In cities where traffic is heavy, signs prohibiting U-turns are often erected. Before making a U-turn, be sure that there are no such signs.

If a U-turn is impractical or illegal, use a side road which is free of traffic as the next best method. If there is a choice, it is safer to use a side road on the right than one on the left because you will not have to back out of the side road into traffic on the main road. To use a side road on the right, drive past the road and stop. Then, after making sure that there is no traffic coming, back into the side road, signal for a left turn, come out of the side road, and turn left. If you use a side road on the left, make a left turn into the road. Back out of the road to the right. Back slowly and keep a sharp lookout for oncoming traffic.

If you cannot make a U-turn and no side road is available, use the road turn. There are two ways of making a road turn. The easiest way is to come to a complete stop at the right curb or edge of the road, using the shoulder if available. Start turning to the left. Turn your steering wheel as quickly as possible and as far to the left as it will go. Just before you get to the left curb or edge, reverse the steering wheel to the right. As you approach the right curb or edge with your rear wheels (backing), turn your steering wheel again to the left. By going forward and keeping your wheel to the left, you should be able to clear the curb or edge this time and complete the turn. If the road is very narrow, you may have to go back and forth once again.

You can also make a road turn by stopping close to the right curb or road edge and backing to the left. When you use this method, you have to be careful to start far enough away from the right curb to keep your right front wheel from going off the road when you start backing to the left. In making these turns, it is not absolutely necessary to reverse your steering wheel just before you stop moving. You can do it after you have stopped. However, turning the wheels while you are still moving is easier and saves wear on the tires and steering mechanism. In business districts, where traffic is usually heavy, no method of turning around may be practical or safe. In such places, the best way to reverse your direction is to drive around a block.

Exercises (805):

1. What must be used besides your accelerator to safely control your speed while backing a vehicle with a standard transmission?

2. When is it permissible to make a U-turn?

3. What type turn requires a sharp left turn while backing up?

806. State procedures for parking a vehicle and list "no parking" situations.

Parking. Parking parallel to a curb and between vehicles is very difficult if you don't learn the proper method and practice it. You can make it seem easy if you follow the step-by-step method shown in figure 1-2. Select a large enough space. You need at least 6 feet more than the length of your vehicle. (More for a large truck.) Twenty-five feet or about a car length and a half is adequate for a sedan in almost any case. Give a hand signal for stopping. Pull up alongside the vehicle parked in the space ahead of the space you intend to use. Your vehicle should be from 1 to 2 feet away from that vehicle, and the rear bumpers of the vehicle should be even. Start backing slowly and turn your steering wheel hard to the right (for right curb parking) as soon as your vehicle starts moving. With your wheel all the way over to the right, continue backing until your vehicle is at a 45° angle to the curb. At this point your right front door will be about opposite the rear bumper of the other vehicle. Now straighten your front wheels and go straight back a short distance until the right end of your front bumper is opposite the left end of the rear bumper of the other vehicle. Pause a moment. Now turn your steering wheel hard to the left and back slowly the rest of the way into the space, straightening out your front wheels just as they approach the curb. If you find that

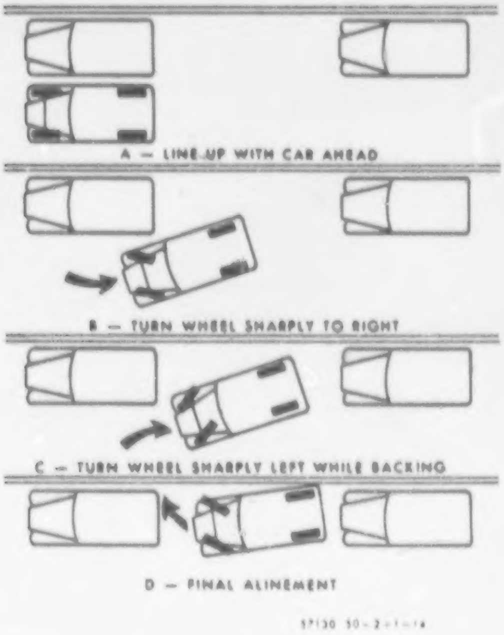
A — LINE UP WITH CAR AHEAD
B — TURN WHEEL SHARPLY TO RIGHT
C — TURN WHEEL SHARPLY LEFT WHILE BACKING
D — FINAL ALINEMENT
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Figure 1-2. Curb parking.

you cannot get all the way into the space, usually the best thing to do is drive all the way out, get your vehicle into proper position beside the vehicle ahead of the space, and start all over again.

Pull forward so that your vehicle will divide the parking space, leaving as much distance between your vehicle and the vehicle ahead as there is between your vehicle and the vehicle behind. Your front and rear wheels should be an equal distance from the curb and no more than a foot away from it. Before you leave your vehicle, you should turn off the engine, set the handbrake, and put your vehicle in reverse gear. If your vehicle has an automatic transmission, place the lever in either the "park" or "reverse" position, depending on the particular transmission. When there is a curb, turn your front wheels left, away from the curb, as shown in figure 1-3. By doing this you will make sure that your vehicle will not roll.

Except on one-way streets, always park on the right side of the street. Get out of your vehicle on the side away from the traffic, and always remember to lock the ignition switch. Most military vehicles will not require the ignition to be locked, but some will. After locking the ignition switch, remove the key and take it with you, both on and off base.

Diagonal, or angle parking, is easy enough for most drivers. However, there are some things you should remember. Give a hand signal before stopping. Begin turning into the parking space from a position about 5 feet from the row of parked vehicles. Turn your steering wheel in the direction of the space and enter the space with your vehicle as straight with the angle of the space as possible. Use the parked vehicle or line marking on your left as a guide, but be very careful to allow enough clearance between your vehicle and the vehicles parked on either side.

When coming out of a diagonal parking space, back very slowly until you are out far enough to see traffic that may be coming, and stop if necessary. Turn your steering wheel sharply when your left front wheel is opposite the rear bumper of the vehicle parked on your left. If you turn sooner, you are likely to sideswipe the other vehicle as you back out. Improper parking may inconvenience and endanger other drivers. Be sure that you do not park:

- Within an intersection or in front of a driveway.
- Within 25 feet of the curb line of an intersecting street, or within 15 feet of the crosswalk at an intersection where there is no curb.
- On a crosswalk, sidewalk, or bridge.
- Within 15 feet of a fire hydrant or entrance to a fire station.
- On a paved or main traveled portion of a rural highway when it is possible to park on the shoulder.
- Unless you can leave at least 15 feet of the road clear for the passage of other vehicles and unless your vehicle can be seen for a distance of at least 200 feet from both directions.
- On the roadway side of another vehicle (double parking).
- Where "No Parking" signs have been erected.

Exercises (806):

1. What is the first step to remember in parallel parking?

2. What is likely to happen if you turn too soon while backing out of a diagonal parking space?

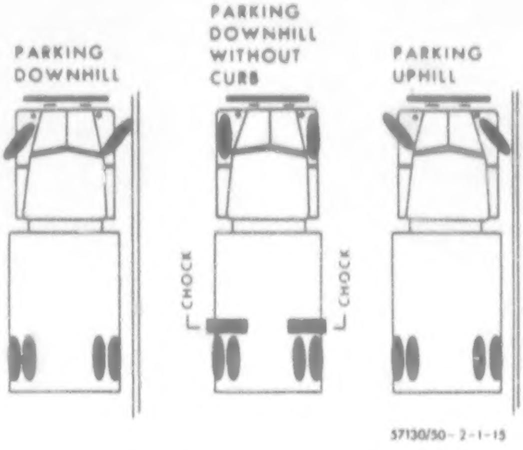

Figure 1-3. How to park on hills.

3. Give eight "no parking" situations.

807. List rules and practices for controlling vehicle speed.

Controlling Speed. In the law books, there are a number of statutes dealing with speed, but the basic one is simply the rule of common sense. *No person shall drive a vehicle on a highway at a speed greater than is reasonable and prudent under the existing conditions.* If you want to live, and want others to live, you will find no traffic law more important than this one. Few of us are good judges of speed. Most of us have had the experience of attempting to slow down to 20 or 25 miles an hour, only to glance at our speedometers and find we were still traveling at 40 or 45 miles an hour. Our judgment of speed is relative. After we have been driving at one speed for some time, we get used to it. We are likely to think that we are going slowly just because we have slowed down a little.

The "existing conditions" are constantly changing as you drive. One minute you are rolling along through open farm country. The next minute you are driving through a small roadside community. A few minutes later, you are passing through a school zone. Controlling your speed demands constant attention to changing conditions. The conditions you should take into consideration in controlling your speed include not only the type of district but also weather, light, sight distance, speed of other traffic, type of road surface, condition of your vehicle, and your own physical condition. Sight distance is especially important. You should always be able to stop your vehicle within the distance you can see ahead.

In addition to the "basic common sense" rule, there are maximum speed limits set by law. Speed limits are usually posted for the driver's information; however, to keep speed reasonable and prudent, it is often necessary to drive slower than the maximum limits but never faster, except as specifically authorized. Certain vehicles are allowed to exceed speed limits in specific situations. Many improvements have been made in the safety equipment of vehicles. Brakes have been made more effective, lights more powerful, and tires more dependable. Yet, it is as true today as it was 50 years ago that the most important safety feature in any vehicle is the control which the driver has over the machine. The faster the vehicle goes, the more of that control the driver gives up, the less chance the driver has of avoiding an accident, and the more deadly an accident will be. Accident statistics show that speed is a factor in a fifth of all accidents and in almost half of the fatal accidents. It affects your ability to turn, pass, stop, and slow down. Nothing is more important to safe driving than careful control of your speed.

High speeds are much more dangerous than low speeds, but the driver who drives so slowly that he prevents other drivers from driving at a reasonable speed is also a serious traffic hazard. Where passing is difficult, the slow driver forces everyone else either to creep along behind him or to risk an accident in trying to get by. Very slow driving is especially dangerous just after you have passed the crest of a hill or rounded a curve, because other drivers may crash into you before they can slow down. In many cases, the slow driver may cause an accident that he escapes himself. If you find it necessary to drive slowly to get a better view of sights, locate an address, etc., park your vehicle, and thereby avoid endangering and irritating other drivers. In some areas, minimum speed limits are posted and these limits will be observed and obeyed with regard equal to that given maximum limits.

Where traffic conditions permit, keep your speed steady. The driver who, for no apparent reason, alternately speeds up and slows down confuses and endangers other drivers. With practice, you can keep your speedometer needle hovering close to the speed at which you intend to drive. A steady speed is not only safer but also more comfortable and economical.

Exercises (807):

1. What are the eight conditions you should consider in controlling your speed?

2. Speed is a factor in what percentage of accidents?

3. Is it possible to drive too slowly?

4. When is driving slowly especially dangerous?

5. What does the practice of speeding up and slowing down create?

808. State basic principles of on the road driving.

On the Road. Fifty years ago, when there were few vehicles and the roads were narrow, there were two simple traffic rules. One required that a driver keep to the right when meeting a vehicle coming from the opposite direction. The other required him to keep to the left when overtaking and passing a vehicle going in the same direction. At other times, a driver could use the center or any other part of the road. It is easy to imagine the confusion and wreckage that would result if these were the only rules followed today. The present law requires us to drive on the right-hand side of the road not only when meeting another car but as a general rule. Driving on the left-hand side of the road is permitted only in certain situations, such as passing. The danger of ignoring this law is obvious. Yet, more than one-seventh of the fatal accidents are the result of head-on and side-swipe collisions which occur because a driver is on the wrong side of the road. Driving with a portion of your vehicle on the wrong side is a violation of this rule.

Why do people drive on the wrong side of the road? One reason is speed. When we are driving fast, we want to be sure that we have plenty of room. We sense the danger of running off the side of the road. Instinctively, we move toward the center. In avoiding one danger, we expose ourselves to another. Another reason we drive on the wrong side of the road is that we fail to concentrate on driving. Our minds are occupied with conversation, settling a quarrel, worrying, or trying to remember detailed instructions given by the supervisor—everything except driving. Our eyes may be off the road and on a passenger in the back seat. The military vehicle driver will refrain from unnecessary conversation while driving. When you are driving, give all your attention to it.

Curves. When we think of vehicle accidents, we are likely to think of one vehicle crashing into another. Thousands of people are killed each year in collisions between vehicles, but more are killed in one-vehicle accidents. A driver loses control of the vehicle, skids off the road, and careens into a telephone pole. Or the vehicle turns over and over as it rolls down an embankment and into a ditch. A curve is a likely place for this kind of accident.

If you took physics in school, you learned two rules about moving bodies. They tend to remain in motion, and they tend to follow a straight path. To make a moving body follow a curved path, you must use force to overcome its natural tendency. A vehicle on a curve is a moving body with a natural tendency to go straight ahead. At each point on the curve, the driver uses force to keep the vehicle turning. The natural tendency to go straight ahead increases much more rapidly than the speed. At 60 miles an hour it takes nine times as much force to keep a car turning as it does at 20 miles an hour.

More important than force is the fact that effective steering depends on the friction between the road and the tires. The part of a tire in contact with the road at any one time is about the area of the soles of your shoes. Four small areas of rubber are the only connection between the road and 2 tons of speeding automobile, with more weight and more wheels in some vehicles. Friction is simply another way of saying that the rubber has a tendency to stick to the road instead of slipping and sliding over it, or that the vehicle has a tendency to move only in the direction that the wheels roll.

If you have ever been in a skid, you know that the grip of friction can be broken. It is broken whenever the tendency of the vehicle to travel in a straight line becomes too powerful for the grip of friction which is holding the vehicle on the curve. The tires slide on the road and the vehicle starts to skid. The rest of the story is the familiar one of wrecked vehicles, broken bodies, hospital bills, and notices in the obituary columns.

As a driver on a curve, the only thing you can do to prevent the opposing forces of nature and steering from breaking the grip of friction is to slow down. Slow down as you approach a curve. Slow down enough so that after you are in the curve, you can keep your engine pulling and maintain your speed. Don't wait until you are in the curve to apply your brakes. If you do, you simply add another force tending to break the grip of friction. The grip of the brakes may be all it takes to break the grip of friction and send your vehicle sliding off the road. If you must apply your brakes in a curve, be careful. Use a gentle pumping motion until you are sure it is safe to keep continuous pressure on the pedal.

Start turning your wheels just before you reach the point at which the road begins to turn. Once in a curve, stay on your own side of the road and stay as far over to the right as you can. Don't try to make a curve easier by cutting across the lane of traffic going in the opposite direction. If your speed isn't too high, the curve will be easy enough on your own side of the road. You can't judge the next curve by the last one. Roads with uniformly sharp or gentle curves are probably safer than roads with curves of varying degrees, but highway improvement is often a piecemeal business. On most roads, the curves vary. To be safe, assume that unfamiliar curves are sharp. You can always speed up if you are wrong. If you make the opposite mistake, you may not be able to slow down.

Exercises (808):

1. What violation of safe driving causes one-seventh of all fatal accidents?

2. What two reasons cause drivers to drive on the wrong side of the road?

3. What does a driver use to turn a vehicle besides the steering wheel?

4. What does effective steering depend on?

5. What happens when the friction between tires and road is broken?

6. What should you expect from any unknown curve in the road?

809. Tell how to use your eyes when driving and the effects of alcohol on driving ability.

Using Your Eyes. Good vision is a part of your natural equipment, but equally important is knowing how to use your eyes while driving. To get a driver's permit, you must be able to see well enough to drive safely. Whether you do see well enough to drive safely depends mainly on how you use the eyes you have. Don't stare vaguely into the distance. Keep your eyes scanning the road in front of you. If the vehicle you are following obstructs your vision of the road ahead, you are probably following much too close.

As you watch the road ahead, don't ignore the roadside. Signs posted along the road give you advance warning of hills, curves, and intersections. They also notify you of speed limits and other regulations. Your eyes should tell you about the movements of vehicles and pedestrians at the side of the road. If you see that a vehicle ahead has pulled over to the curb, be on guard because the driver may suddenly open the door and step out into the traffic. Exhaust vapors coming from a parked vehicle should tell you that the driver may suddenly pull away from the curb and into your path. When you see children on the sidewalk throwing a ball back and forth, you should slow down and be ready to stop. One of them may chase the ball into the street. Things such as these are danger signals. You will be able to avoid accidents if you see them and understand them, but you won't see them unless you look for them.

Looking for a parking space or an address can be dangerous if it causes you to give too much of your attention to the side of the road. You know that you intend to stop when you find the parking place or address, but other drivers probably don't. So long as you remain in the stream of traffic, keep watching the road ahead and checking your mirror for vehicles behind. Also, remember to warn other drivers of your intentions.

Sometimes when you are making a left turn at an intersection, your vision of traffic coming from the right will be obstructed by a passenger sitting beside you on the front seat. Unless vehicles are redesigned to move the driver's portion of the front seat forward of the rest of it, you will have to use extra effort to get a clear view in this situation. Lean forward so that you can see around your passenger. If necessary, ask them to lean back to give you a better view.

Some things which you may see on the road are important to safe driving. Others are not. You haven't time to see both. Good driving vision is "selective vision" specially adapted to the needs of safe driving. At all times, you need to know where the road is going, the position of the other vehicles, what they are doing or what they may do, and how close you are to them. When you encounter another vehicle, you don't have time for details which would interest you if you were looking at it in a dealer's showroom.

Alcohol. While it is an understood fact that drinking on duty can jeopardize your position in the military service, it also must be stressed that "alcohol plus gasoline equals blood" and loss of both life and property. Automobile makers are experimenting with engines which run on a mixture of alcohol and gasoline. No one will deny that putting the alcohol in the engine is a much better way of mixing these two volatile liquids than putting gasoline in the engine and alcohol in the driver. If you drink, you may or may not be able to handle your liquor and your vehicle.

In an average year in the United States, over 10,000 people are killed in traffic accidents in which a driver or a pedestrian had been drinking. Most of these people had not drunk enough to be considered intoxicated, but there is reason to believe that the driver who has had a drink or two may be even more dangerous than the one who is clearly drunk. Persons who have had only one or two drinks, usually don't realize that their driving ability is impaired. They often think they can drive better. "Whiskey courage" is an old story. On the highway, it is a tragic one. Drinkers may learn to control themselves and disguise the fact that they have been drinking. They may be able to fool some people. You, as a military vehicle operator, may be able to fool your supervisor or other authorities. You are not likely to fool your vehicle, a machine which is often more than a match for people even when they are sober.

Alcohol is not the only thing that impairs driving ability. Barbiturates, antihistamines, and other medicines in common use may make people sleepy. If you do not know whether the medicine you are taking has this effect, ask your doctor or druggist. If they say that it will make you sleepy or that it might, don't take it before driving. You have to stay alert to stay alive. If you have experienced loss of sleep or for some other reason you feel an unusual sleepiness to the point that you think your driving may be unsafe, notify your supervisor. He will adjust your duties accordingly and thereby preclude the danger of loss of life and property. This does not excuse the driver from keeping himself physically capable of performing his duty. Repeated incidents of this nature should result in a required physical checkup and/or disciplinary action.

Exercises (809):

1. What should your eyes be doing while you are driving?

2. What should you be looking for while driving?

3. What should you do to help other drivers?

4. What should you do if you believe your driving is unsafe?

5. What effect does alcohol have on your driving ability?

810. For given instances state the recommended practices of safe following and passing.

Following and Passing. Following too closely is one of the four leading causes of accidents. It accounts for most of the read-end collisions. A few years ago, rear-end collisions, while frequent, were not likely to result in much more than damage to the vehicles involved. Today, when rear-end collisions occur on fast modern highways, drivers and passengers in the rear car are thrown forward against windshields and dashboards with skull-cracking force. Those in the front car frequently receive "whiplash" injuries to the neck and upper spine. The rear-end collision has become a major killer. There is no reason for you to become one of the increasing number of victims. All you have to do is watch your speed and keep your distance. Proper use of seat belts will also help.

The safe rule for following is this: Allow 20 feet, a little more than one car length, for each 10 miles an hour of speed. For example, if the speed of two vehicles is 40 miles an hour, the following distance should be 80 feet. If the vehicles are traveling 50 miles an hour, the following distance should be 100 feet. An easy way to remember this rule is that the following distance in feet should be twice the speed.

Following at night. When you are following another vehicle at night, your headlight beams may be reflected in the rearview mirror of the vehicle ahead and tend to blind its driver. You can avoid this by increasing your following distance or by lowering your headlight beams. However, the second method should be used only when there is sufficient light so that the distance you can see ahead is greater than the distance needed to stop your vehicle.

Exercises (810):

1. Why has following too closely become a major killer in vehicle accidents?

2. What is the recommended minimum distance you should allow when following a vehicle traveling at 60 mph?

3. How can you avoid shining your headlight beams into the eyes of the driver ahead of you?

811. List facts about safety in passing.

Passing. To pass or not to pass—as a driver, you must make this decision over and over again every time you drive. Some drivers take chances. They move out into the left-hand lane as soon as they see any possibility of getting past the vehicle ahead. Others let opportunities for safe passing go by while following a slow moving vehicle for mile after mile of growing irritation. Safe passing depends primarily on knowing two things: when not to pass and how to pass. You cannot pass safely unless you can see far enough ahead to be sure that you can get back in line before you meet any traffic coming from the opposite direction. You must also be able to get back into line before meeting any traffic crossing or turning into the road on which you are driving. There are some places where you never can be sure and where passing is always dangerous and unlawful, as illustrated in figure 1-4, and stated here:

- On any curve or hill where you cannot see at least 500 feet ahead.

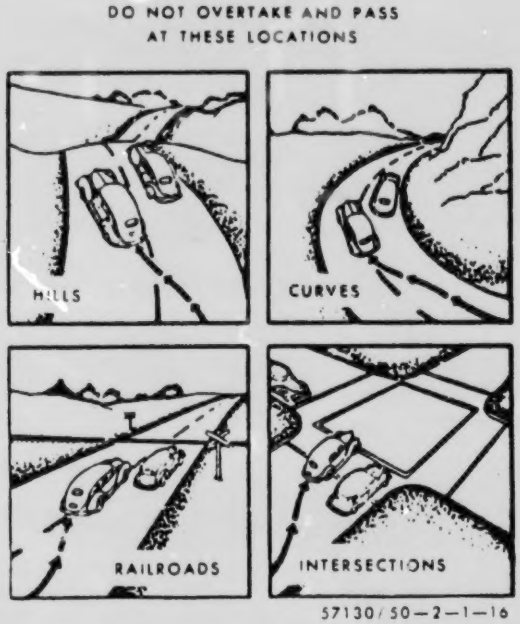

Figure 1-4. When NOT to pass.

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- At intersections and railway crossings.
- Whenever there is a solid yellow line in your lane or a single solid line between lanes.
- At crosswalks where a car has stopped to allow a pedestrian to cross.
- Wherever you cannot see that the road is free of traffic far enough ahead to pass safely.

The last rule above sums up all the others and raises the question: How far ahead is "far enough ahead"? It depends on the speed of the vehicle you are passing, your own speed, and the length of the vehicles involved. Suppose you want to pass a vehicle traveling 30 miles an hour. You will have to travel whatever distance it travels while you are passing and an additional distance besides. Since the speed is 30 miles an hour, the additional distance in this case will be about 160 feet. It is generally a good idea to pass at a speed at least 10 miles an hour faster than the speed of the car being passed. If your speed is only 5 miles an hour faster, it takes you twice the time and twice the distance to get by. On the other hand, there is no point in passing too fast. There is a relatively small advantage to be gained by passing at 20 instead of 15 miles an hour faster than the speed of the vehicle being passed. This small advantage of only 1 or 2 seconds gained is usually more than offset by the danger of increased speed. If too much speed increase is required to pass and return to your lane, the wise decision is not to pass.

As a general rule, your passing speed should be from 10 to 15 miles an hour faster than the speed of the vehicle you are passing. Suppose, however, that you want to pass a vehicle traveling 50 miles an hour when the speed limit is 55 mph. In this case, driving your vehicle 10 or 15 miles an hour faster would be unlawful, because passing is no excuse for exceeding the speed limit. Yet, if you pass at 55 miles an hour, you will need 2,640 feet or exactly half a mile. When the driver ahead of you is traveling just under the speed limit, the safest thing to do is to forget about passing. Settle down behind him at a safe following distance. You may reach your destination a few minutes later than if you attempt to pass, but at least you are more likely to get where you are going.

Exercises (811):

1. What two things must you know in order to pass a vehicle safely?

2. What two points will prohibit you from passing a vehicle traveling 50 mph in a 55 mph zone?

3. List the five times it is dangerous or unlawful to pass.

4. If a vehicle is traveling at 40 mph, what is your recommended passing speed?

812. Specify safety practices to be observed while passing.

Passing on the right is usually dangerous and unlawful. It puts you on the blind side of the driver of the other vehicle. He may be intending to make a right turn to pull over to the right side of the road. If he does, an accident is almost certain. There are, however, four situations in which passing on the right is sometimes permissible and reasonably safe; on highways having at least two lanes going in each direction, on one-way streets where all lanes of traffic move in the same direction, when moving past a vehicle which is in a left turn lane, and when driving in a lane set aside for right turns only.

What about three-lane highways? On these highways, you must not pass except in the center lane and then only when the center lane is marked for passing in your direction. The one exception to this rule is that you may pass in the right lane if the vehicle in the center lane is making a left turn. When passing, don't just pull out and start around. Look ahead and behind to be sure it is safe to pass. Let the driver of the vehicle ahead know what you intend to do. He may be getting ready to pass the vehicle ahead of him or to turn left. The driver of the vehicle behind also wants to know what you are going to do. He may be pulling out to pass you. Blow your horn as a signal to the driver ahead. Give a left-turn signal to let the driver behind know that you are about to pull out to pass. The horn signal is required by law in most localities, and it puts the driver of the vehicle being passed under a legal obligation to help you pass.

Give yourself and the driver of the vehicle you are passing plenty of room. Start to pass from a safe following distance. If the vehicle you want to pass is traveling 30 miles an hour, you should start from at least 60 feet behind and allow 60 feet after passing before getting back into your lane (20 feet for every 10 miles an hour of speed). Also allow an additional distance for the length of the two vehicles, a total of 160 feet.

Drift over to the left and speed up quickly. Do not speed up directly behind a vehicle and then turn out suddenly just before you get to it. This interferes with your view of the road ahead. The other driver may slow down or stop, and he can do so much more quickly than you can because his speed is lower. If he does, you will almost certainly be unable to slow down or stop in time. If you try to avoid a collision by turning sharply aside, you may skid off the road, turn over, or smash into another vehicle. As you go by another vehicle, be sure there is plenty of distance between the right side of your vehicle and the left side of the other vehicle. The law in most localities requires a minimum clearance of 2 feet. You have not

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finished passing until you get back onto your own side of the road or the lane in which you belong, leaving the vehicle you have just passed at a safe following distance behind you. If the vehicle you are passing is traveling 30 miles an hour, leave 60 feet clear before returning to your own side of the road (20 feet for every 10 miles an hour of speed). If you force the driver of the vehicle you have just passed to slow down as you get back into line, you have not passed safely. Of course, it is difficult to see the vehicle you have just passed and estimate the distance. Here is a good rule of thumb: You can usually be sure it is safe to return to the right side of the road when you can see the vehicle you have just passed in your rearview mirror.

As a general rule, do not attempt to pass more than one vehicle at a time. Passing several vehicles increases the danger because it increases the time you spend and the distance you cover while out of your own lane. If you come in behind a long line of vehicles, you can be almost sure that every driver except the first one is waiting for an opportunity to pass. The safe and courteous thing to do is to wait your turn. Passing on a three-lane highway demands extra caution. The center lane may be so marked that it is open for passing in both directions. Before passing, make sure that none of the vehicles coming from the opposite direction are moving out to pass. On a three-lane highway, never use the center lane to pass if your view of the road ahead is obstructed by a hill or curve.

Exercises (812):

1. Name the situations in which it is permissible to pass on the right.

2. On three-lane highways, which lane is designated as the passing lane?

3. What rule of thumb is used by the driver of a passing vehicle to judge when it is safe to return to the right side of the road?

4. How many vehicles should be passed at one time?

813. Cite practices you should follow while being passed.

Being Passed. When you are being passed, the law requires you to help the other driver get by. When the driver of the passing vehicle blows his horn, there is one thing you must do: give way to the right. Even if you are already on your own side of the road, you should move over, as close as safety will permit, to the right-hand edge of the road. There is one thing the law does not permit you to do, and that is to increase your speed. Speeding up forces the passing driver to cover more distance and take more time in getting by you. It exposes him and you to unnecessary danger.

When being passed, it is usually safest to maintain a steady speed. By doing this, you allow the passing driver to judge his passing distance with greater accuracy. If you slow down, you may mislead the passing driver into overestimating his speed. Nevertheless, if an attempt to pass becomes dangerous, you may be able to make it safer for everyone by slowing down and allowing the passing vehicle to get back into the proper lane in less time and distance. If, however, you see that a driver is trying to get back into line behind you, rather than ahead of you, don't slow down. In this case, it is much safer to speed up a little and give him more room. When danger develops in passing, don't stand on your rights. Use all your driving skill to avoid an accident.

Exercises (813):

1. What does the law require you to do while being passed?

2. What does the law prohibit you to do while being passed?

3. When is it justifiable to speed up when being passed?

814. State proper procedures to be followed when driving in the vicinity of an emergency vehicle.

Emergency Vehicles. Police cars, ambulances, and firefighting/rescue vehicles are entitled to the right of way whenever they give a visual and/or audible warning of their approach. The audible warning is usually a siren, sometimes a bell. Additional warning is usually given by a flashing red or blue light. The law requires you to drive to the right-hand curb or edge of the road and come to a complete stop. You must remain stopped until the emergency vehicle has passed, or until you are directed to start again by a police officer. Though laws and regulations require you to pull to the right side of the road, they do not require you to do it carelessly or without regard to the consequences. Be sure to look before you turn your steering wheel. If you turn suddenly to the right without looking, you may collide with the emergency vehicle to which you are attempting to yield the right-of-way.

Never follow a firetruck or other emergency vehicle and do not drive into or park in a block in which a fire department vehicle has stopped in answer to a fire alarm. If you do, you will expose yourself to unnecessary danger and may hinder the work of the fire department. Never drive over a firehose unless directed to do so by a firefighter or a police officer.

Exercises (814):

1. If approached by an emergency vehicle, what are you, as a driver, required to do?

2. Is it safe to follow an emergency vehicle?

3. Never cross over a firehose unless directed to do so by whom?

815. Cite procedures to be followed in the event of of breakdown.

Breakdowns. If your vehicle breaks down, get it off the main traveled portion of the road if possible. If you have a flat tire, there is a risk that you will damage the tire beyond repair if you drive on it, but you should take this risk if necessary to avoid greater danger. When your vehicle is disabled at night, always leave your parking lights on as a warning to other drivers. For added safety, set the electrical turn signals, if you have them, so that they will flash on the left side, or set the 4-way flashers. If you cannot get your vehicle off the road and it is hidden from approaching drivers by a curve or hill, walk back along the road to a position where you can signal them to stop in time. Do not attempt to make repairs on your vehicle while it is in an exposed position on the road. If on base, contact your supervisor, dispatcher, or service station maintenance crew by radio, telephone, or a passing driver.

Exercises (815):

1. If you cannot get your vehicle off the road and it is hidden from approaching drivers, what action should you take?

2. If the breakdown occurs on base, what action should you take?

816. Explain what to do during given driving emergency situations.

Driving Emergencies. The best way to handle emergencies is to avoid them. Although some emergencies are unavoidable, most of them are created by drivers who are driving too fast, driving carelessly, or failing to take proper care of their vehicle. Yet, once in danger, the important thing is not how you got into it, but how you can get out of it. The techniques discussed here are not fool-proof, but they will give you a better chance of avoiding a serious accident.

Blowouts. A driver gets no warning before a blowout. There is usually a loud report, and the vehicle immediately starts swerving to one side or swaying dangerously. Use all your strength on the steering wheel to keep the car going straight ahead. Don't apply the brakes until the engine has slowed the car and you are sure you have it under control.

Skids. If you start to skid, you may be able to regain control if you do the following things:

- Ease up on the accelerator and do not apply the brakes. Keep your vehicle in gear. If the skid occurs when you are braking, take your foot off the brake. It may be necessary to feed gas carefully to reduce the braking effect of the engine. In either case, the reason for the action is to keep the wheels from slowing down too quickly and making the skid worse.
- At the same time, turn your wheels in the direction of the skid. If the rear end of your vehicle is skidding to the right, turn your steering wheel to the right. If it is skidding to the left, turn your steering wheel to the left. Do not turn the steering wheel too sharply or keep it over too long. If you do, you may start skidding in the opposite direction. Ease the steering wheel back to the center position as you recover from the skid and regain control of your vehicle.
- Let the engine slow your vehicle gradually. If you use your brakes to stop, do not hold the pedal down, but pump it gently until you come almost to a complete stop. If you start to skid to the left and turn your wheels to the left, you may steer into oncoming traffic on the other side of the road. On the other hand, almost all skids can be avoided if you drive slowly enough, and if you stop, start, and turn slowly enough on slippery surfaces.

Exercises (816):

1. What action should you take if you experience a blowout?

2. If you experience a skid, which way should you turn your wheels to effect recovery?

3. How can most skids be avoided?

817. State actions to be taken in case you run off a road or have a brake failure.

Running off the Pavement. If you run off the of the pavement and onto the shoulder, do not apply your brakes or try to turn back onto the pavement immediately. If you do, you may skid or turn over. Take your foot off the accelerator and steer straight ahead, allowing the engine to slow you down. When you have slowed enough to have the vehicle under control, look to see if there is any traffic coming. If there is not, turn your front wheels to the left enough to ride over the pavement and not skin the sidewalls, and drive back onto the pavement.

Brake Failure. If your brakes fail, you may still be able to get your vehicle stopped in time to avoid an accident. Pull on the handbrake and shift into a lower gear. Let the clutch pedal out and turn off the ignition. If your vehicle is equipped with an automatic instead of a standard transmission, move the control lever into the low-range position.

After driving through water, you should immediately test your brakes to determine whether they are operating properly. If they fail to function, it will probably be due to wet linings. You can dry the linings by continuing to drive at a slow speed with sufficient pressure on the brake pedal to cause a slight drag. The heat generated by the partially applied brakes will dry your brake linings. Before going down steep grades, shift to a lower gear to control your speed and prevent excessive wear of your brake linings.

Exercises (817):

1. What is the best action to take with the steering wheel if you turn off of the pavement?

2. What are the four steps which will help bring a vehicle, equipped with a standard transmission, to a stop if the brakes fail?

3. Outline the method of drying wet brake linings.

818. Explain what is meant by the term "the lesser evil" as it applies to driving.

The Lesser Evil. Sometimes you can avoid a serious accident only by deliberately choosing a less serious one. Suppose you are driving at about 50 miles an hour on a two-lane road. Two vehicles are appraching from the opposite direction on the other side of the road. When they are fairly close to you, the second one suddenly pulls out to pass the first one. If you cannot stop or slow down in time, the only thing for you to do is to head for the right shoulder, even if it means an accident. If you stay where you are, you will have a head-on collosion with the vehicle coming at you on the wrong side of the road. If you swerve to the left, you will probably have a head-on collision with the other vehicle. The right shoulder may be dangerous, but almost any kind of accident is preferable to a head-on collision.

Another example: Suppose you are being passed by one vehicle and there is another vehicle not far behind you. As the passing vehicle draws even with you, a small animal runs out on the road ahead of you. You must make an unpleasant decision and make it quickly. If you swerve suddenly to the left, you will collide with the passing vehicle. If you swerve to the right, the soft surface of the shoulder may turn your vehicle over. If you stop suddenly, you will probably be hit by the vehicle behind. You do not want to hit the animal, but it is the safest thing to do. If you do anything else, the animal may be killed anyway, and several human beings may also be killed or injured.

Exercises (818):

1. What is meant by choosing "the lesser evil"?

2. Why may it be necessary to hit a small animal rather than try to avoid hitting it?

819. Identify the fire prevention practices to be used by the driver of a military vehicle

Vehicle Fires. When fueling the vehicle engine, you must have it switched off. No smoking or open flames should be permitted within 50 feet of a vehicle during fueling, nor at an accident scene where there is danger from spilled gasoline or other flammables. CAUTION: Keep the gasoline nozzle in contact with the gas tank when fueling. Do not use gasoline to clean a vehicle or vehicle parts. Use only approved cleaning materials. When flares are authorized, instructions for their storage on the vehicle and handling will be issued. Since flares are a potential fire hazard, it is imperative that drivers take the prescribed precautions. (NOTE: Flares will not be attached to a vehicle after they are ignited.)

When transporting explosives or flammable cargo you will not smoke and you will not allow passengers to smoke. Nor will you allow your vehicle to become exposed to open flames or explosions when loaded with flammables or explosives. Vehicles designed for the transportation of bulk flammable liquids will be permanently marked with warning placards. When a general-purpose vehicle is used to transport gasoline or other liquid fuels, it will be your responsibility to attach the prescribed warning placards on your vehicle. When you are dispatched to transport dangerous cargo, ask your supervisor for special instructions and warning placards for your truck. Since laws vary between states and countries, you may be required to have available more than one set of placards. CAUTION: When dispensing fuel to another vehicle or tank, you must secure a ground cable to the dispensing vehicle and the vehicle or tank being filled.

You may have only limited resources for fighting a vehicle fire, so send for help from other firefighters when possible. Your firefighting equipment usually consists of a hand fire extinguisher and any natural materials such as sand and water that may be available. These resources, when applied at the initial state of a fire, have a good chance of bringing it under control. However, once the fire has reached major proportions, you place yourself in danger with little possibility for success when you attempt to extinguish it with inadequate equipment.

Exercises (819):

1. For what distance should no smoking or open flames be permitted while fueling?

2. What should be used to clean vehicles or vehicle parts?

3. Are you, as a military driver, allowed to smoke in a military vehicle?

4. How will vehicles designed to transport bulk flammable liquids be marked?

5. Who is responsible for attaching the correct warning signs to a vehicle?

820. Determine the correct fire extinguishment procedures to follow in given instances.

Engine Fire. When you discover your vehicle is on fire, bring it to a halt and dismount, taking your fire extinguisher with you. Direct the contents of your extinguisher at the base of the flame until the fire is out or your extinguisher contents are exhausted. If the fire continues to burn after your extinguisher has been emptied, use sand or earth to smother the flame, provided you can get it to the base of the flame without excessive risk of personal injury. Since most vehicle fires involve gasoline, oil, or electricity, water should not be used. CAUTION: When attempting to extinguish a fire, keep the wind to your back. In this position, the flames and fumes from the fire will be blown away from you.

Cargo Fire. If a fire starts in your semitrailer, it may be necessary to drop it to save your tractor or vice versa. Cargo fires in trucks and trailers are usually discovered by smelling or observing smoke escaping from around doors or from under the tarpaulin. When this condition is discovered, do not open the cargo doors or remove the tarpaulin until you have moved your vehicle to a safe location where help can be obtained, preferably from a fire department, or wherever an adequate source of firefighting equipment is available. After help has been obtained, the doors may be opened cautiously, or the tarpaulin partially removed and the source of the fire located. Locating the source of the fire may entail removing part of the cargo. (NOTE: Fires in a closed van or under a secure tarpaulin can only smoulder due to lack of oxygen.)

Wheel/Tire Fire. Tires, when underinflated, generate excessive heat during operations. This condition, especially on dual wheels, may result in the tire ignition. Tires dragged along the road surface due to a locked wheel may commence burning. Fires resulting from these conditions can be prevented by keeping your tires properly inflated, promptly recognizing any difference in the performance of your vehicle that would indicate a locked wheel, and then promptly taking corrective action. If a tire does start burning on your vehicle, you may not be able to extinguish it with your firefighting equipment; however, you may prevent further damage by employing the following measures. When possible, remove the wheel from your vehicle and attempt to extinguish the fire by covering it with sand, earth, mud, or water. If the wheel cannot be removed with safety, drive your vehicle into sand, mud, or water and cover any exposed tire parts with mud or similar substance. When the fire cannot be controlled, you should use your vehicle firefighting equipment or other suitable substance to prevent the fire from spreading. Do not attempt to transport the tire on your truck unless the fire is completely extinguished and the tire has cooled to normal temperature.

Exercises (820):

1. At what portion of the flame should you direct the contents of your extinguisher?

2. Why should you avoid using water on a vehicle fire?

3. When attempting to extinguish a vehicle fire, you should keep the wind to what part of your body?

4. Why is it important not to open the cargo doors of a semitrailer that is on fire?

5. When is it safe to go on after experiencing an overheated tire?

821. Explain principles of flight line operations.

Flight Line Vehicle Operation. Motor vehicles operating on the flight line are necessary to normal operations and maintenance. However, they present a clear and possible danger, both to aircraft and ground personnel. Carelessness, haste, and disregard of existing safety standards by flight line vehicle operators is inexcusable and is the primary source of aircraft-vehicle collisions and personnel injury. Applicable directives covering flight-line vehicle traffic will be followed.

Only those operators and vehicles designated by the base commander will be given access to the flight line. These operators, before driving on the flight line, will be given special instructions on standard flight line traffic controls and tower signals and advised of the particular hazards involved. A record of this instruction will be entered on the operator's DD Form 1360, Operator Qualifications and Record of Licensing, Examination and Performance, and their operator's permit will be "overstamped." No other person will be allowed to operate a vehicle on the flight line except for specified short periods of time, and only by temporary written permission of the base operations officer. Permits for driving on flight lines will be kept to a minimum, consistent with operational requirements.

Exercises (821):

1. What are the primary causes of vehicle-aircraft collisions and personnel injury?

2. Which operators and vehicles are allowed access to the flight line?

3. How is it shown that a driver is authorized to operate on the flight line?

822. State the operating standards to be observed in given instances while operating on the flight line.

Operating Standards. The following standards of operation will be observed at all times when you are operating vehicles on the flight line. Careful attention and strict adherence to these precautions will prevent accidental damage to aircraft and possible injury to both flight and ground personnel.

Vehicles will not pass under any part of an aircraft, unless absolutely necessary. In those instances, the operator will make a visual check to be certain that there is sufficient clearance before proceeding. Vehicles, also, will not be backed in the direction of any aircraft except as authorized in certain towing, loading, unloading, or fueling operations. In these cases, where backing toward the aircraft is necessary, post a guide as a required safety measure, with bumper chocks placed to prevent vehicles from backing into the aircraft. All vehicles should approach parked aircraft with the driver's side of the vehicle toward the aircraft.

Passengers in or on military vehicles will display particular caution. They will remain seated while the vehicle is in motion and keep their arms and legs within the vehicle body. Passengers will not ride on tug fenders unless a suitable seat with a back and side guard is installed, nor will they ride on any part of moving equipment not designed especially for passengers. Passenger-carrying vehicles will stop at the side of aircraft only when actually loading or unloading personnel.

Under no circumstances will vehicles stop in front of, or drive into, the path of taxiing aircraft except "guide" or "follow-me" vehicles, nor will other vehicles drive between the aircraft and its "follow-me" guide. For maximum personnel safety, no vehicle will stop, park, or be driven closer than 25 feet in front of any aircraft or less than approximately 200 feet from the rear of an aircraft whose engines are operating or about to be started. Safe distances to the rear of specific aircraft will be as published in applicable aircraft directives (handbooks).

You must be particularly cautious when it becomes necessary to drive across runways. You must come to a complete stop at least 100 feet from the runway and not proceed until you have received a signal light or radio clearance from the control tower. Periodically all installations make a survey of vehicle runway crossing conditions to be certain that flight safety is not being compromised. If runway crossing conditions make it necessary, additional traffic signals that are electrically controlled from the tower will be installed. All flight line vehicles must come to a full stop before entering or crossing a taxiway. Before proceeding, you must determine visually that the way is clear. Except in unusual cases, general-purpose vehicles will not operate at speeds greater than 15 miles per hour while on the flight line. Special-purpose vehicles should not exceed 10 miles per hour, and no vehicle must operate in excess of 5 miles per hour when in close proximity to aircraft. During emergencies, fire and crash equipment and ambulances may exceed limits only when personnel and property are not endangered by such speed.

Vehicle headlights shining toward a moving aircraft at night should be turned off immediately so that the pilot will not be blinded or their night vision affected. The vehicle parking lights should be turned on, however, so that its position will be known. The headlights should remain out until the aircraft is out of range. Vehicles on the flight line are a major source of foreign objects which damage aircraft tires and are ingested into jet engines with disastrous results. Before operation on the airfield, operators will check that all equipment carried on their vehicles is properly stowed and secured and that vehicles are inspected for objects that could cause damage to aircraft. When dual-wheeled vehicles are operated on unpaved surfaces, they frequently pick up rocks between the tires. Stop when reaching the airfield pavement and remove any rocks or other foreign objects which are wedged between the tires or treads.

A serious accident potential exists when vehicles are operated in the path of radio beams used for aircraft navigation. Flight line vehicle operators will be instructed by their supervisors concerning the location and necessary precautions to be taken when operating near such equipment. Drivers will stop when emergency vehicles are seen or heard. Ignition will be turned off, brakes set, chocks put in place, and the gear lever placed in reverse or park when the driver's seat is vacated.

Exercises (822):

1. Why should unauthorized vehicles not be backed in the direction of aircraft?

2. When approaching a parked aircraft what side of your vehicle should be towards the aircraft?

3. What is the closest a vehicle can park in front of an operating aircraft?

4. How close to a runway may a vehicle come before it must stop and await a signal from tower?

5. What are the speed limits to be observed on the flight line?

6. What headlight precaution should be observed around a moving aircraft?

823. Explain signals from control towers and "follow-me" vehicles.

Control Tower Signals. Flight line vehicles are under the control of tower personnel. The light signals and radio instructions must be observed and obeyed by all vehicle operators. Control tower light signals will be posted in plain view of vehicle operators on either the dash panel or other appropriate location. Operators of radio-equipped vehicles will comply with flight line traffic instructions received from the control tower. Vehicles not equipped with radio will obey light signals from the tower. The following light signals flashed from the control tower will control flight line vehicle traffic:

- Steady green light—Clear to cross.
- Flashing green light—Cleared to proceed and watch for lights.
- Steady red light—Clear active runway immediately.
- Flashing white light—Return to starting point.
- Red and green light—General warning. Exercise extreme caution.

Follow-Me Vehicles. Follow-me vehicles used for guiding aircraft will be equipped with signs easily visible at night, reading "Stop" and "Follow Me." They are also equipped with 2-way radio facilities for communication on control tower frequencies. When approaching the parking spot, the follow-me vehicle operator should illuminate the "Stop" signal, move the vehicle from the intended path of aircraft travel and position it laterally, clear of the aircraft wingtip. The marshaller, who may be the vehicle operator, will then proceed to guide the aircraft to the parking spot by use of marshalling signals contained in applicable Air Force directives. In order to accommodate the optimum safe taxiing speed of aircraft, guiding follow-me vehicles will be permitted to exceed the normal 15 miles per hour flight line speed limit. Tugs will not be used as follow-me vehicles at any time.

Exercises (823):

1. What does the steady green light from tower mean?

2. What does the red and green signal from tower mean?

3. What two signs are used on a follow-me vehicle?

4. What vehicle will not be used as a follow-me vehicle?

824. State recommended procedures for driving across ditches, gullies, and ravines.

Driving Under Difficult Conditions. You can easily cross shallow ditches by shifting into low gear or range and proceeding slowly. Enter obliquely so that one wheel leaves the ditch as the other wheel on the same axle enters it. In crossing deep ditches, use the lowest forward gear and front wheel drive if the vehicle is so equipped. When you reach the bottom, accelerate enough to keep rolling as you go up the other side. If the ditch is deep and has very steep sides, you may have to cut away the tops of the banks before attempting to cross.

Gullies and ravines are natural formations caused by running water. Look these formations over carefully before crossing in order to find a place to cross and to insure that your vehicle can get across. Be sure to examine both banks. Your vehicle approach should be made slowly, in low gear, and at a right angle to the edge so that both front wheels enter at the same time. Using the footbrake, ease the front wheels into the gully squarely so that both of them strike the bottom at the same time. Bring the engine up to normal operating speed as the wheels hit bottom, accelerating enough to climb as the front wheels touch the opposite bank.

Exercises (824):

1. What gear should be used to cross a ditch?

2. At what angle should you enter a gullie or ravine?

825. List special problems of, and solutions for driving through woods or over rocky terrain.

Woods tend to conceal you and your vehicle from air observation, and they also present certain problems. Fairly open woods with trees at least as far apart as the width of your vehicle will allow passage, provided you are able to maneuver your vehicle around the trees. Use an established trail if possible. If it is necessary to drive through dense growth, center the larger saplings on the vehicle bumper. Don't plan to return by the same route because these same saplings may stop your vehicle when braced against you. If the woods are too dense and prevent your passage, drive as closely as possible to the edge where the trees are smaller and less dense. A high tree stump, if straddled, can cause serious damage to the axles and other low parts of your vehicle. Moreover, tires are injured by stumps. Drive with caution. When you drive through wooded country, whether on country roads or cross country, low-hanging limbs may break or damage top-mounted equipment. Survey the route to determine whether your vehicle can proceed without damage from low-hanging limbs and whether it is practicable to remove obstructing limbs. A heavy log can often be crossed by piling dirt or other material on each side and then driving over it. Do not attempt to straddle large boulders because they will damage axles and other low parts of your vehicle. Move very slowly. When driving in very rocky terrain, you should carry an extra spare tire if one is available as there is greater danger of flats. Remove stones from between dual tires as often as possible to prevent breaking the sidewalls of the tires.

Exercises (825):

1. What special problems does driving in wooded areas present?

2. When driving through wooded areas, what route should be used?

3. Why should stones be removed from between dual tires?

826. State recommended procedures for driving in mud or swamps.

Every military vehicle has enough power in lowest gear to pull out of mud, provided it gets traction. Try to pull out slowly in low gear or low range if your vehicle is equipped with an automatic transmission. Traction can be increased by placing boards, brush, or similar material under the vehicle wheels. Select the gear that will get you through, roll onto the soft area at a medium speed for the selected gear, and carefully maintain a steady throttle until you reach solid ground. If you are stopped by mud rolling up in front of your wheels, you may have to back off and hit it again with regained momentum. Under most conditions this technique requires prompt action; otherwise, the mud will fill the tracts behind your wheels and slow or stop your backing. This technique requires solid footing within the reach of your vehicle. If you get stuck, try to pull out slowly in low gear or low range if your vehicle is equipped with an automatic transmission. If you can't pull out and if brush or boards do not provide the traction you require, then get another vehicle to pull you out. When other vehicles are not available and your vehicle is equipped with a winch, attach your winch cable to a tree or other solid object and pull yourself out with winch power. Don't attempt to rock a heavy vehicle because it will only dig in.

If you must cross a stream, check the stream bottom to determine how firm a support you can expect. If you expect some sinking, determine if this, when added to the water depth, will exceed your vehicle's fording limit. If the fording limit will be exceeded, find another crossing point. After reaching dry land, apply the brakes a few times to help dry the brake linings.

Exercises (826):

1. What speed should you use when driving in mud?

2. Why is it not recommended to rock a large vehicle when stuck?

3. What should you do if the point you have selected to cross a stream is above the recommended fording limits of your vehicle?

827. Cite general procedures for driving in sand.

Driving in Sand. The main objective when driving in sand is to maintain movement with the least amount of strain on the vehicle, its engine, and power train. You can do this by:

- Estimating the roadability of a sandy area.
- Adjusting tire pressures to meet changing conditions.
- Using various aids to improve bearing surfaces.
- Exercising sound driving techniques.

Your ability to do these things better will come through practice and experience.

Tire pressure. Reduce tire pressure when driving in soft sand and over dunes. This will increase the amount of tire surface in contact with the sand to provide better flotation (support). However, never reduce tire pressure so low that the tire slips on the rim. Refer to your vehicle manual for proper tire pressures. When operating with reduced tire pressure, drive at low speed. Inflate tires to normal pressure (cross country or hard surface as appropriate) as soon as the situation permits.

Correct sand driving techniques:

- Insure that you have proper tire pressure.
- Normal engine starting procedures apply.
- Select a gear or range that will start you without (or with a minimum of) clutch slippage and wheel spinning.
- Accelerate gradually.
- Maintain a steady and even rate of movement.
- Avoid unnecessary shifting of gears. If your vehicle is equipped with an automatic transmission, keep it in low range.
- Anticipate difficult spots and attempt to bypass them.
- When necessary to cross a small stretch of soft sand, head for it with increased speed to take advantage of momentum.
- To cross an extensive stretch of soft sand, stop before entering it, reduce tire pressure as necessary and start off in a gear or range which you believe will take you through with little necessity for further shifting and a minimum of clutch slippage and wheel spinning. As soon as the necessity for low-tire pressure ceases, stop and reinflate your tires if your vehicle is equipped with the air connections and system.

To operate over a dune (hills of sand piled up by the wind), approach the windward slope (most gradual slope) straight on, after selecting the proper gear and range in order to avoid shifting while on the slope. Maintain as much momentum as possible while going up the slope and be prepared to change direction as you reach the crest. Ride the crest if necessary to seek a safe descent. When the lee (steep) slopes must be used, select a point where the angle of approach will allow the front bumper to clear, and proceed as follows:

- Conditions and feel will indicate whether it is best to follow in the tracks of preceding vehicles or to break a new path.
- Make wide turns. Sharp turns can stall or even overturn your vehicle.
- When possible or practical, permit the vehicle to roll to a halt, otherwise, brake gradually. This prevents tires from digging in when brakes are used.
- Try to stop on a downhill slope. This will give you an advantage when starting.

At the first sign that your vehicle is bogging down, try a lower gear. If you still are bogging down:

- Stop power to the driving wheels. Continued attempts at using the motor to force the vehicle out of the sand at this time will only sink it deeper into the sand, thus making it more difficult to get out.
- Check the tires for sand operation inflation; high temperatures may have built up the pressure.
- Lower tire pressure if necessary for emergency movement over a short distance.
- Now try to drive on.

If the use of lowered tire pressure alone is not enough to free the vehicle, the procedure below, as possible or necessary, should be followed:

- Shovel a clear path ahead of the wheels.
- Lay boards, brush, channels, canvas, wire netting, rope ladders, or some similar material under and in front of the tires to give better flotation and traction.
- Use a winch or a tow if it becomes evident that continued operation of the vehicle under its own power will only cause it to sink deeper into the sand.
- In the event a vehicle is "bellied down" in deep ruts or loose sand and must be pulled out, unload the vehicle as much as possible.

Exercises (827):

1. What is the main objective in sand driving?

2. What action should you take to improve your traction when driving on soft surfaces?

3. If possible, from which side should a sand dune be aprroached?

4. Explain how a vehicle should be brought to a stop in sand.

828. Explain practices of winter driving.

Particularly during cold weather operations, you must exercise extreme care in starting and operating your vehicle. Your vehicle must be kept in the best mechanical condition possible; otherwise, it will not operate properly. Carbon monoxide poisoning presents an added hazard. Poisoning is the result of inhaling the exhaust fumes of the vehicle and usually results in death. To avoid it, never sleep in the cab of your vehicle with the engine or heater running. Whenever the heater is used while driving, leave a window open slightly. Inspect the vehicle exhaust manifold, muffler, and tailpipe for serviceability and tightness daily. Never leave the engine running while working on the vehicle in a closed building. Some points to remember for cold weather driving are:

- Vehicles equipped with mud and snow tires will slide more on icy road surfaces than those with commercial tread. Mud and snow treads are most effective on roads covered with loosely packed snow.
- All-wheel-drive vehicles without chains generally perform better than two-wheel-drive vehicles with chains on the rear wheels only.
- Chains give a good bite in snow or mud and are better than a plain tire on ice or packed snow.
- Sand, cinders, or dirt scattered on icy road surfaces give more traction than chains.
- Fresh snow may conceal an icy road surface.
- Although snow or ice may be melting on roads, it may remain solidly packed or frozen on bridges.
- Better traction is gained when the load is distributed even on all wheels.
- From 3 to 11 times greater distance is required to stop a vehicle on pavement covered with ice or snow.
- Alertness for isolated patches of ice, especially in shaded areas, is essential to safety.

If you expect unusual road conditions, whether mud, sand, ice, or snow, you should have the vehicle equipped with tire chains. Tire chains should be installed on all driven or powered wheels, and even on nonpowered wheels in severe conditions of slickness, since this will help in braking and steering. Tire chains will not damage the tires excessively if they are not installed too tightly (this allows them to creep on the tire) and if you do not drive on hard surfaced roads at high speeds.

Driving a vehicle, as you must be aware of by now, requires much knowledge. What you have read in this chapter only begins to give you the total knowledge you will need to be an expert. With experience and more study, however, you will become a better driver. Never think you have enough knowledge or experience in the field of driving. There will always be new, different, and unusual conditions arising that will show you that more knowledge and experience is always helpful.

Exercises (828):

1. Why is it so important not to breathe carbon monoxide?

2. What substances applied to icy surfaces provide better traction than chains?

3. Which wheels should be chained to provide the best traction on slick surfaces?

CHAPTER 2

Inspection and Maintenance of Vehicles

IF FIREFIGHTING vehicles are in excellent condition, they will be ready to serve their intended purpose and will be safe for their operators to use. When you ride a fire vehicle, your safety depends to a great extent upon the condition of the vehicle. To make sure that fire control and rescue operations are completed in a safe, speedy, and economical manner, you will find that it will be to your advantage to perform regular vehicle inspections and preventive maintenance checks. All firetrucks are inspected and maintained at regular intervals to make sure that they are safe and dependable to operate.

As with most other procedures in the fire protection career field, corrective measures must be taken before it is necessary for the vehicle to go into action. When the alarm sounds, it is too late to perform maintenance duties or to learn operational procedures. It is also too late to prevent yourself from becoming the victim of an accident caused by faulty maintenance and inspection routine. In this chapter you will learn the inspection and maintenance procedures for the various vehicles normally assigned to a fire department. You will also learn how to use the inspection records required for each vehicle.

2-1. Vehicle Inspections and Inspection Forms

Operator Inspection Guide and Trouble Report forms are provided for the different equipment types to assist vehicle and equipment operators in accomplishing required daily inspections and servicing, and to provide a monthly record of inspections, discrepancies reported and maintenance corrective actions. To provide adequate space for a monthly record, the forms are designed on a standard format for all equipment types using 8-inch by 10½-inch card stock paper with center fold to approximate 5 inch by 8 inch size.

829. Identify forms used during daily inspection of assigned vehicles, their governing directive, and facts about these forms.

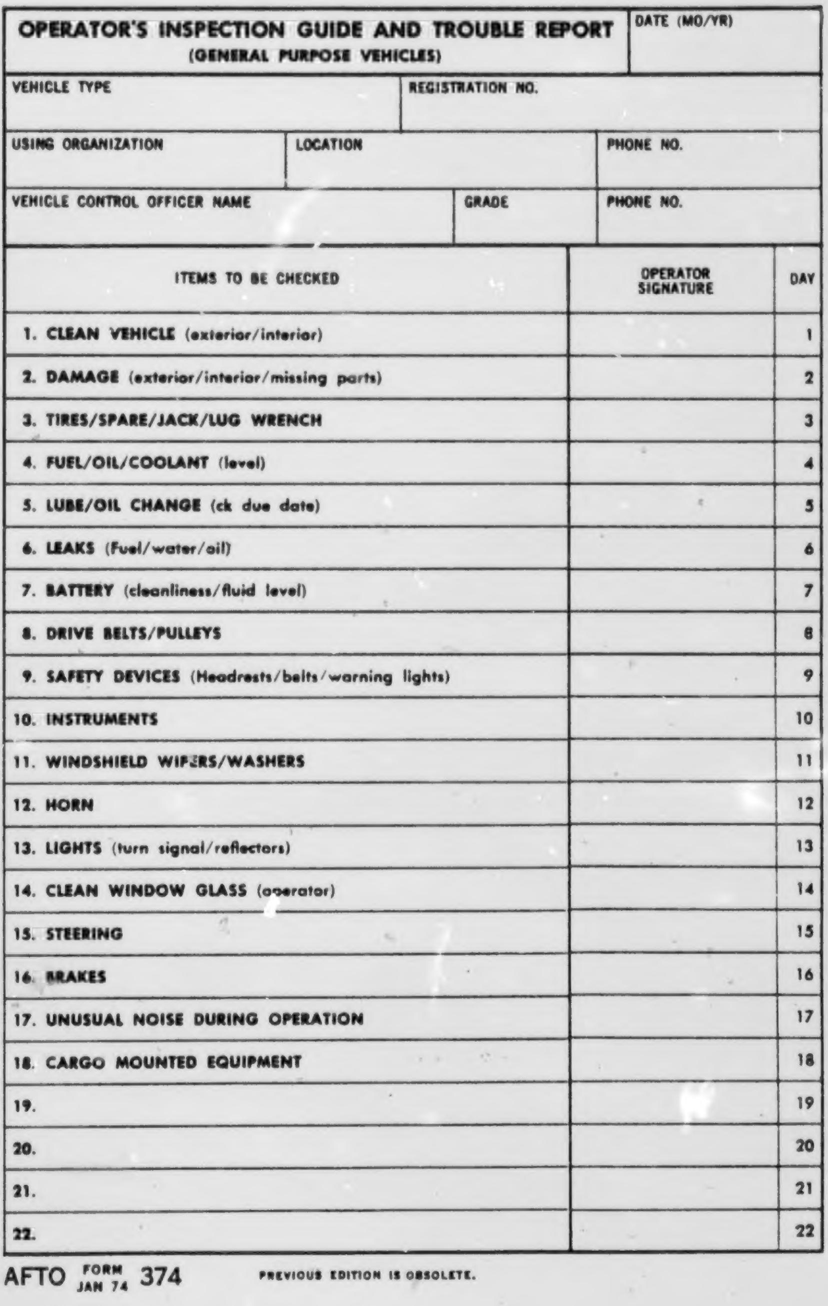
The Inspection Guide. The inspection guide form for the current month is required to be available on all active vehicles/equipment except during maintenance at which time the form is either attached to the work order, in maintenance control for updating, or being reviewed by the Vehicle Control Officer. The vehicle control officer will insure that new forms are initiated for each vehicle at the first daily inspection of the month. The operator performing the first daily inspection of the month will insure that all applicable entries on the previous month form are transcribed to the new form in accordance with procedures in AFM 77-310, VOL 2, VEHICLE MAINTENANCE MANAGEMENT, CHAPTER 7. Vehicles in extended repair or storage, or those waiting disposition at the end of the month will not require initiation of a new form until they return to operational status. The completed inspection guide forms will be retained on file by the vehicle control officer for one month after closeout; or when no longer required for reference purposes, they will be destroyed.

Daily inspections and servicing will be performed by vehicle/equipment operators using the appropriate Operator's Inspection Guide and Trouble Report form and procedures as prescribed in this section. A complete daily inspection, including all items listed in the "Items to be checked" section, is required once each day (24-hour period) when the vehicle/equipment is in use. Wherever switch operations prevail (operators/crews exchange vehicles), operators will verify that the daily inspection has been completed and documented on the inspection guide form. In addition, the new operator will make a brief walk-around visual inspection and check fluid levels as necessary to detect any damage to the equipment, servicing required, or operating problems that may have developed after the daily inspection was accomplished. The only documentation required for this switch inspection is entry of any additional discrepancies found in the maintenance record section of the inspection guide form.

AFTO Form 374. The AFTO Form 374, Operator's Inspection Guide and Trouble Report (General Purpose Vehicles), figures 2-1, 2-2, and 2-3, is designed to assist the driver in checking general purpose vehicles. This inspection form, and others discussed in this section, will be filled out as prescribed in TO 00-20B-5 and your own local directives.

AFTO Form 433. The AFTO Form 433, Operator's Inspection Guide and Trouble Report (P-2/4, O-11A/B, R2-R2A, P-10 Firefighting Vehicles), figures 2-4, 2-5, and 2-6, is used while inspecting those vehicles indicated and any others which are closely related to them but not covered by a specific form. AFM 77-310, #2 should be checked for a full list of AFTO forms used during vehicle inspections.

AFTO Form 434. The AFTO Form 434, Operator's Inspection Guide and Trouble Report (530A/B, 750A, P-6, P-8, P-12, 1000/1500 Gallon Water Distributors, F-6 and F-7 Foam Distributors), figures 2-7, 2-8, and 2-9, like the AFTO Form 433, is used during the inspection of the indicated vehicle and/or related vehicles. The same rules apply for its use as for the 433 and the same TO should be checked.



OPERATOR'S INSPECTION GUIDE AND TROUBLE REPORT
(GENERAL PURPOSE VEHICLES)

DATE (MO/YR)

VEHICLE TYPE

REGISTRATION NO.

USING ORGANIZATION

LOCATION

PHONE NO.

VEHICLE CONTROL OFFICER NAME

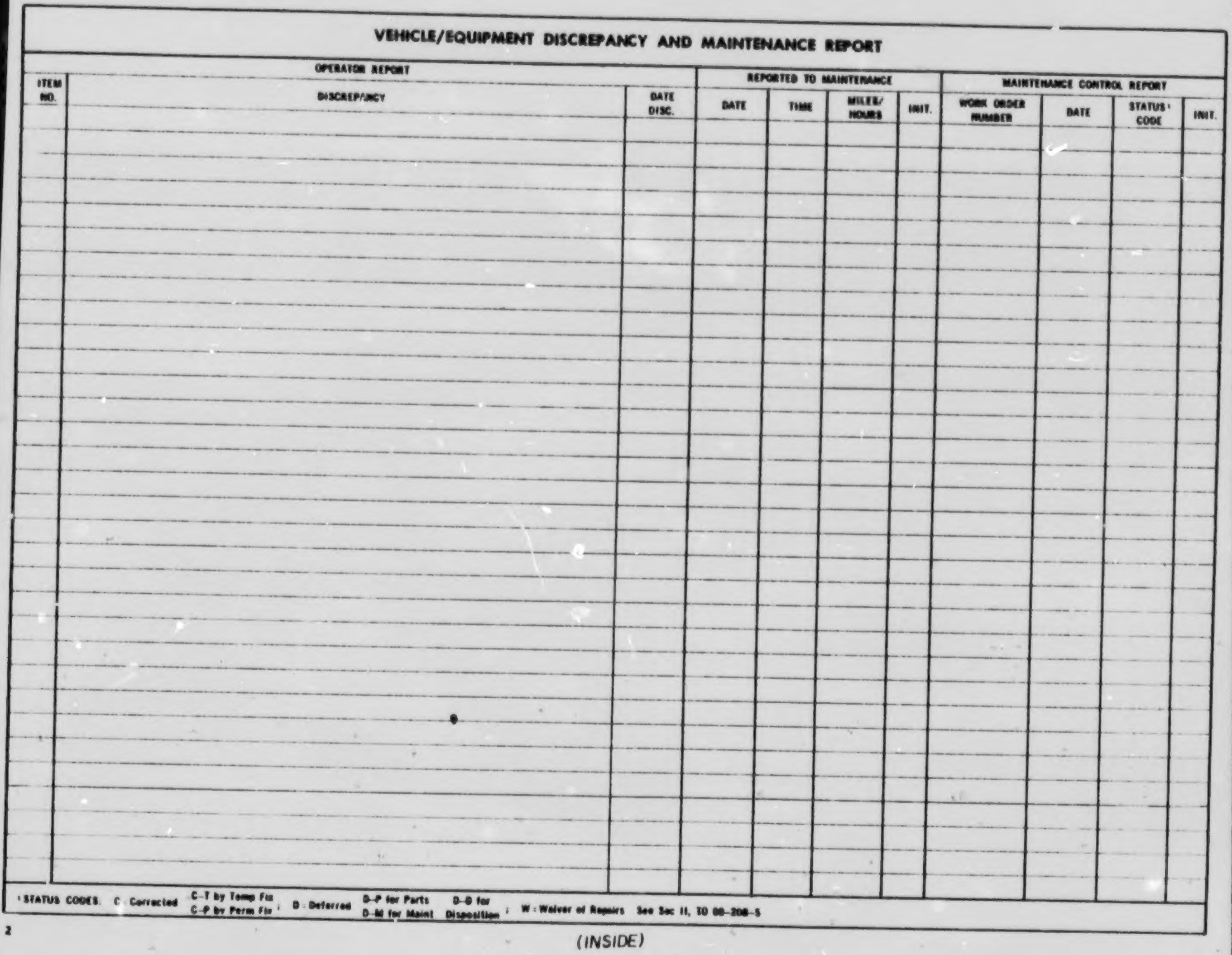
GRADE

PHONE NO.

ITEMS TO BE CHECKED	OPERATOR SIGNATURE	DAY
1. CLEAN VEHICLE (exterior/interior)		1
2. DAMAGE (exterior/interior/missing parts)		2
3. TIRES/SPARE/JACK/LUG WRENCH		3
4. FUEL/OIL/COOLANT (level)		4
5. LUBE/OIL CHANGE (ck due date)		5
6. LEAKS (Fuel/water/oil)		6
7. BATTERY (cleanliness/fluid level)		7
8. DRIVE BELTS/PULLEYS		8
9. SAFETY DEVICES (Headrests/belts/warning lights)		9
10. INSTRUMENTS		10
11. WINDSHIELD WIPERS/WASHERS		11
12. HORN		12
13. LIGHTS (turn signal/reflectors)		13
14. CLEAN WINDOW GLASS (operator)		14
15. STEERING		15
16. BRAKES		16
17. UNUSUAL NOISE DURING OPERATION		17
18. CARGO MOUNTED EQUIPMENT		18
19.		19
20.		20
21.		21
22.		22

AFTO FORM JAN 74 374 PREVIOUS EDITION IS OBSOLETE.

Figure 2-1. AFTO Form 374 - Front.



VEHICLE/EQUIPMENT DISCREPANCY AND MAINTENANCE REPORT

OPERATOR REPORT			REPORTED TO MAINTENANCE				MAINTENANCE CONTROL REPORT			
ITEM NO.	DISCREPANCY	DATE DISC.	DATE	TIME	MILES/ HOURS	INIT.	WORK ORDER NUMBER	DATE	STATUS[1] CODE	INIT.

[1] STATUS CODES. C : Corrected C–T by Temp Fix C–P by Perm Fix ; D : Deferred D–P for Parts D–M for Maint D–D for Disposition ; W : Waiver of Repairs See Sec II, TO 00-208-5

2

(INSIDE)

Figure 2-2. AFTO Form 374 - Inside.

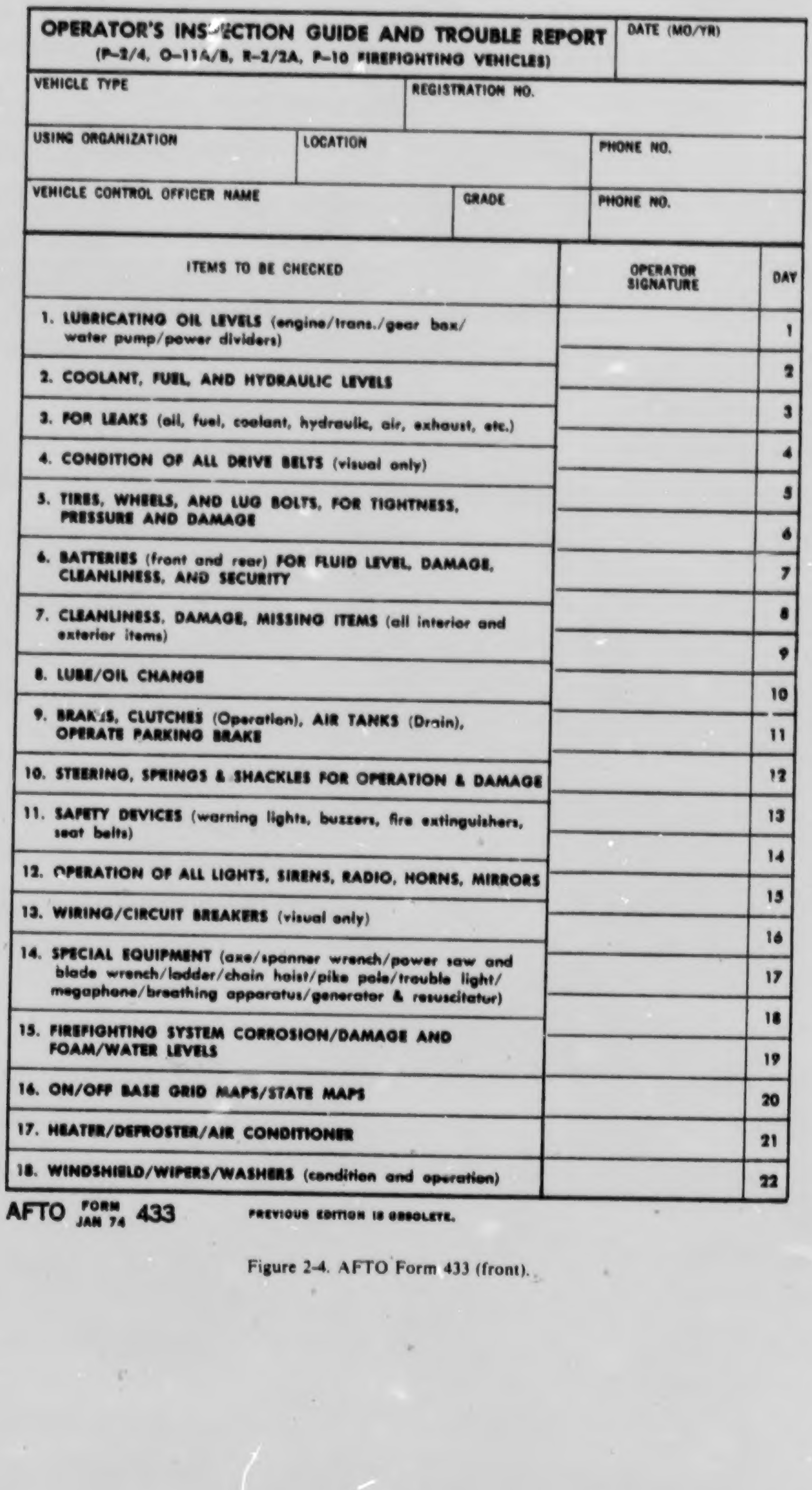
ITEMS TO BE CHECKED (CONT'D)	OPERATOR SIGNATURE	DAY
23.		23
24.		24
25.		25
26.		26
27.		27
28.		28
29.		29
30.		30
31.		31
32.		
33.		
34.		
35.		
36.		
37.		
38.		
39.		
40.		
41.		

42. SPARK CHECK (Weekly and Scheduled Inspection Intervals)

TYPE INSPECTION (Weekly or Sched)	DATE DUE	DATE ACCOMP	OPERATOR OR MECHANIC SIGNATURE AND GRADE

☆ U.S. GOVERNMENT PRINTING OFFICE: 1974— 757-163

Figure 2-3. AFTO Form 374 - Back.



OPERATOR'S INSPECTION GUIDE AND TROUBLE REPORT
(P-2/4, O-11A/B, R-2/2A, P-10 FIREFIGHTING VEHICLES)

DATE (MO/YR)

VEHICLE TYPE

REGISTRATION NO.

USING ORGANIZATION

LOCATION

PHONE NO.

VEHICLE CONTROL OFFICER NAME

GRADE

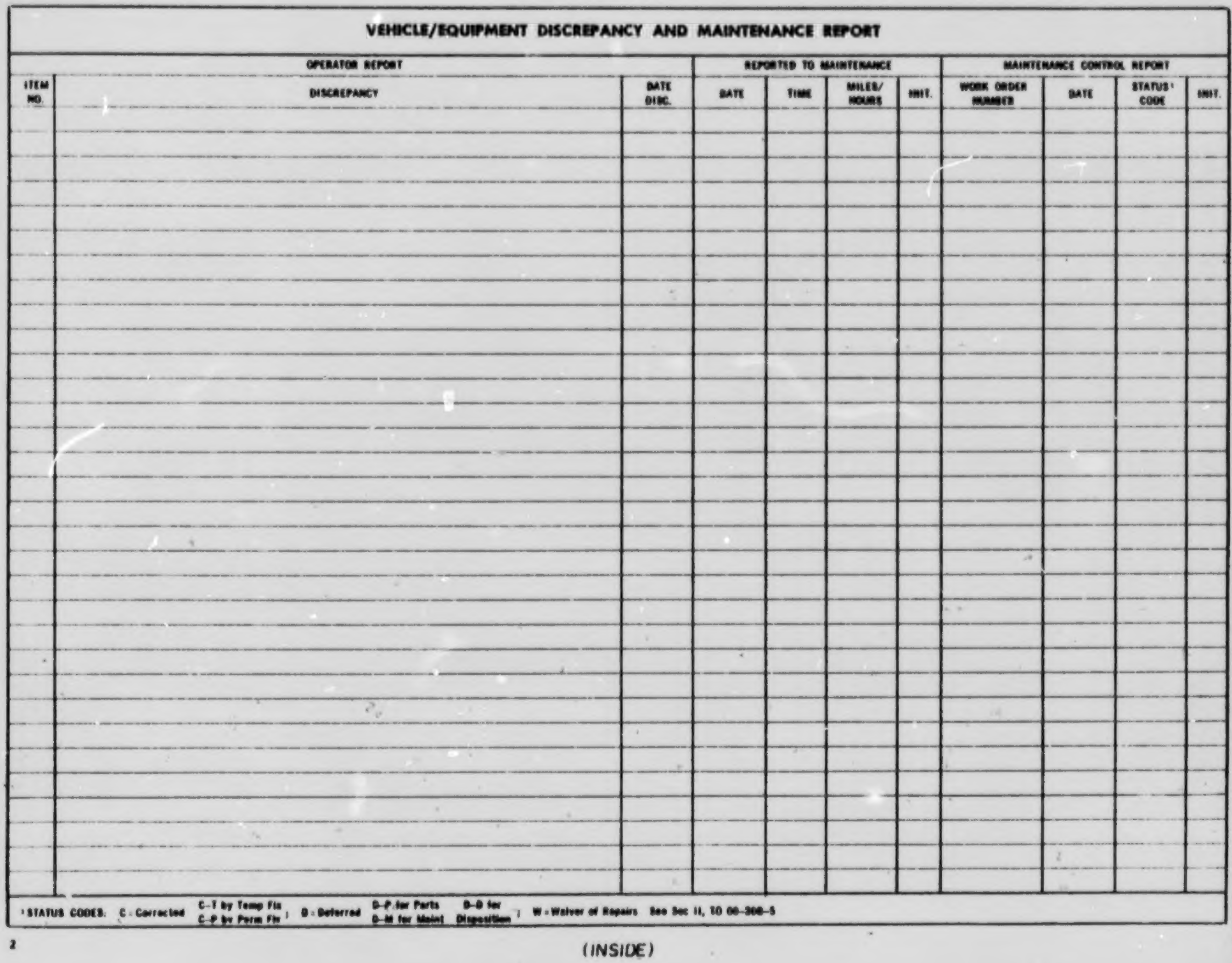
PHONE NO.

ITEMS TO BE CHECKED
1. **LUBRICATING OIL LEVELS** (engine/trans./gear box/ water pump/power dividers)
2. **COOLANT, FUEL, AND HYDRAULIC LEVELS**
3. **FOR LEAKS** (oil, fuel, coolant, hydraulic, air, exhaust, etc.)
4. **CONDITION OF ALL DRIVE BELTS** (visual only)
5. **TIRES, WHEELS, AND LUG BOLTS, FOR TIGHTNESS, PRESSURE AND DAMAGE**
6. **BATTERIES** (front and rear) **FOR FLUID LEVEL, DAMAGE, CLEANLINESS, AND SECURITY**
7. **CLEANLINESS, DAMAGE, MISSING ITEMS** (all interior and exterior items)
8. **LUBE/OIL CHANGE**
9. **BRAKES, CLUTCHES** (Operation), **AIR TANKS** (Drain), **OPERATE PARKING BRAKE**
10. **STEERING, SPRINGS & SHACKLES FOR OPERATION & DAMAGE**
11. **SAFETY DEVICES** (warning lights, buzzers, fire extinguishers, seat belts)
12. **OPERATION OF ALL LIGHTS, SIRENS, RADIO, HORNS, MIRRORS**
13. **WIRING/CIRCUIT BREAKERS** (visual only)
14. **SPECIAL EQUIPMENT** (axe/spanner wrench/power saw and blade wrench/ladder/chain hoist/pike pole/trouble light/ megaphone/breathing apparatus/generator & resuscitator)
15. **FIREFIGHTING SYSTEM CORROSION/DAMAGE AND FOAM/WATER LEVELS**
16. **ON/OFF BASE GRID MAPS/STATE MAPS**
17. **HEATER/DEFROSTER/AIR CONDITIONER**
18. **WINDSHIELD/WIPERS/WASHERS** (condition and operation)

OPERATOR SIGNATURE	DAY
	1
	2
	3
	4
	5
	6
	7
	8
	9
	10
	11
	12
	13
	14
	15
	16
	17
	18
	19
	20
	21
	22

AFTO FORM JAN 74 433 PREVIOUS EDITION IS OBSOLETE.

Figure 2-4. AFTO Form 433 (front).



VEHICLE/EQUIPMENT DISCREPANCY AND MAINTENANCE REPORT

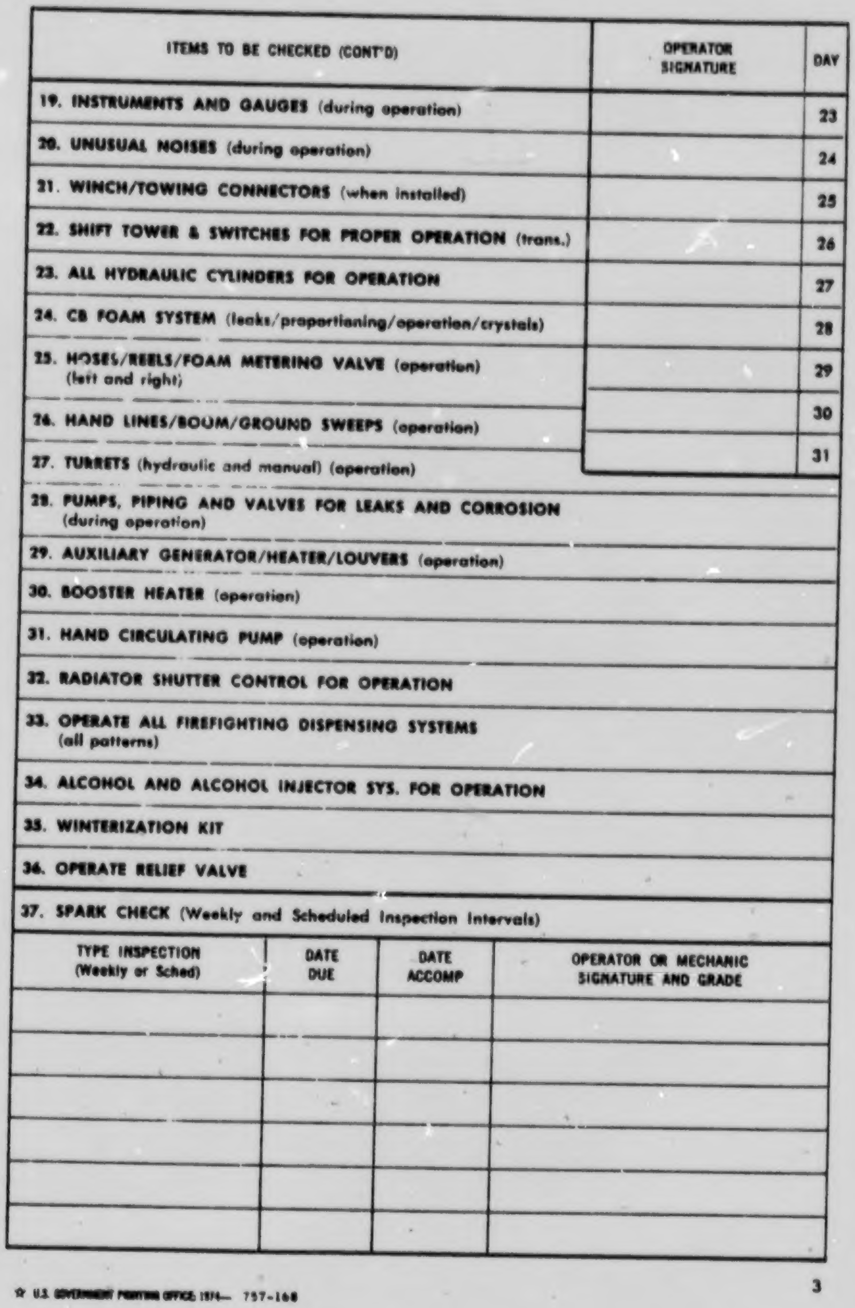
OPERATOR REPORT			REPORTED TO MAINTENANCE				MAINTENANCE CONTROL REPORT			
ITEM NO.	DISCREPANCY	DATE DISC.	DATE	TIME	MILES/ HOURS	INIT.	WORK ORDER NUMBER	DATE	STATUS[1] CODE	INIT.

[1] STATUS CODES: C = Corrected C–T by Temp Fix / C–P by Perm Fix ; D = Deferred D–P for Parts / D–M for Maint D–D for Disposition ; W = Waiver of Repairs See Sec II, TO 00-20B-5

2

(INSIDE)

Figure 2-5. AFTO Form 433 (inside)



ITEMS TO BE CHECKED (CONT'D)	OPERATOR SIGNATURE	DAY
19. **INSTRUMENTS AND GAUGES** (during operation)		23
20. **UNUSUAL NOISES** (during operation)		24
21. **WINCH/TOWING CONNECTORS** (when installed)		25
22. **SHIFT TOWER & SWITCHES FOR PROPER OPERATION** (trans.)		26
23. **ALL HYDRAULIC CYLINDERS FOR OPERATION**		27
24. **CB FOAM SYSTEM** (leaks/proportioning/operation/crystals)		28
25. **HOSES/REELS/FOAM METERING VALVE** (operation) (left and right)		29
26. **HAND LINES/BOOM/GROUND SWEEPS** (operation)		30
27. **TURRETS** (hydraulic and manual) (operation)		31

28. **PUMPS, PIPING AND VALVES FOR LEAKS AND CORROSION** (during operation)

29. **AUXILIARY GENERATOR/HEATER/LOUVERS** (operation)

30. **BOOSTER HEATER** (operation)

31. **HAND CIRCULATING PUMP** (operation)

32. **RADIATOR SHUTTER CONTROL FOR OPERATION**

33. **OPERATE ALL FIREFIGHTING DISPENSING SYSTEMS** (all patterns)

34. **ALCOHOL AND ALCOHOL INJECTOR SYS. FOR OPERATION**

35. **WINTERIZATION KIT**

36. **OPERATE RELIEF VALVE**

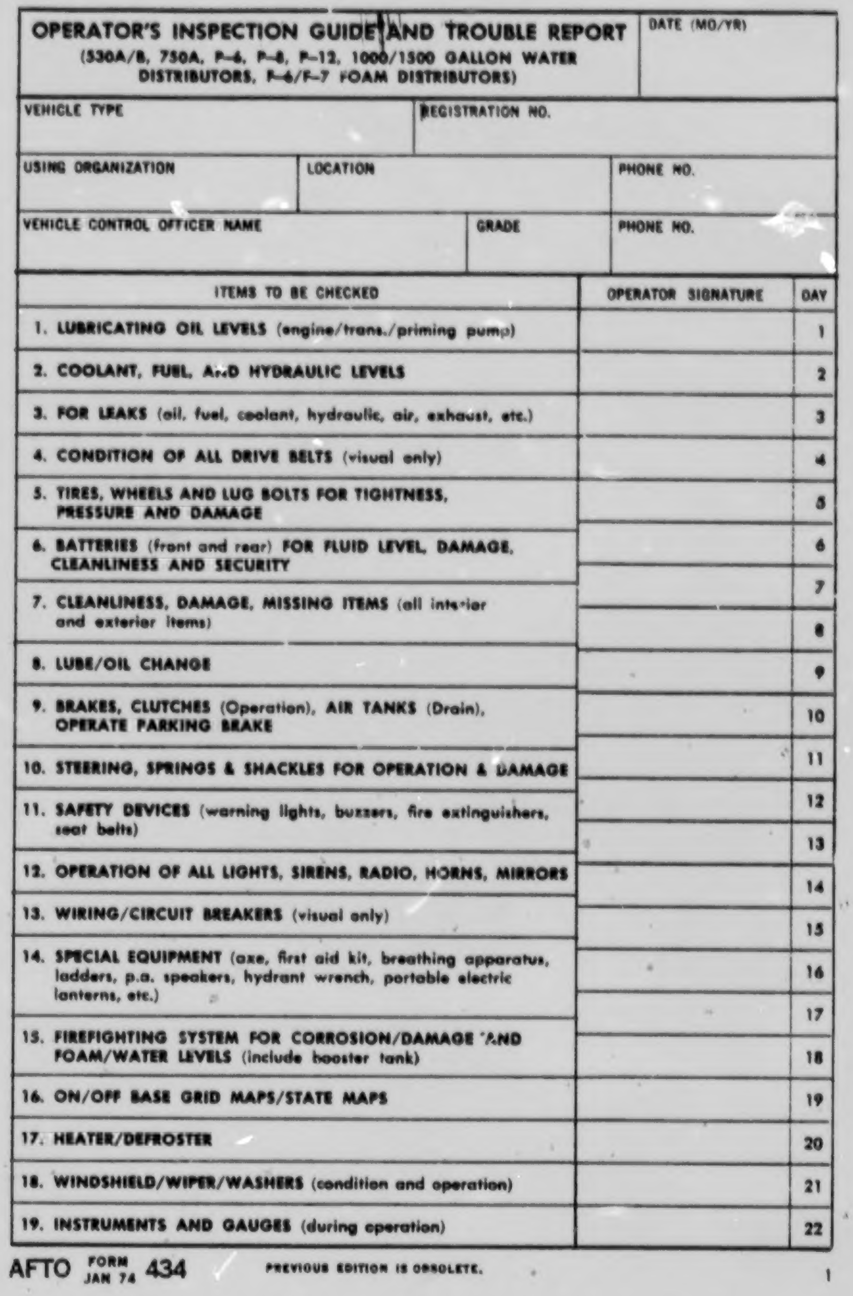
37. **SPARK CHECK** (Weekly and Scheduled Inspection Intervals)

TYPE INSPECTION (Weekly or Sched)	DATE DUE	DATE ACCOMP	OPERATOR OR MECHANIC SIGNATURE AND GRADE

☆ U.S. GOVERNMENT PRINTING OFFICE: 1974— 757-168

3

Figure 2-6. AFTO Form 433 (back).



OPERATOR'S INSPECTION GUIDE AND TROUBLE REPORT (530A/B, 750A, P-4, P-8, P-12, 1000/1500 GALLON WATER DISTRIBUTORS, P-6/P-7 FOAM DISTRIBUTORS)	DATE (MO/YR)

VEHICLE TYPE	REGISTRATION NO.	
USING ORGANIZATION	LOCATION	PHONE NO.
VEHICLE CONTROL OFFICER NAME	GRADE	PHONE NO.

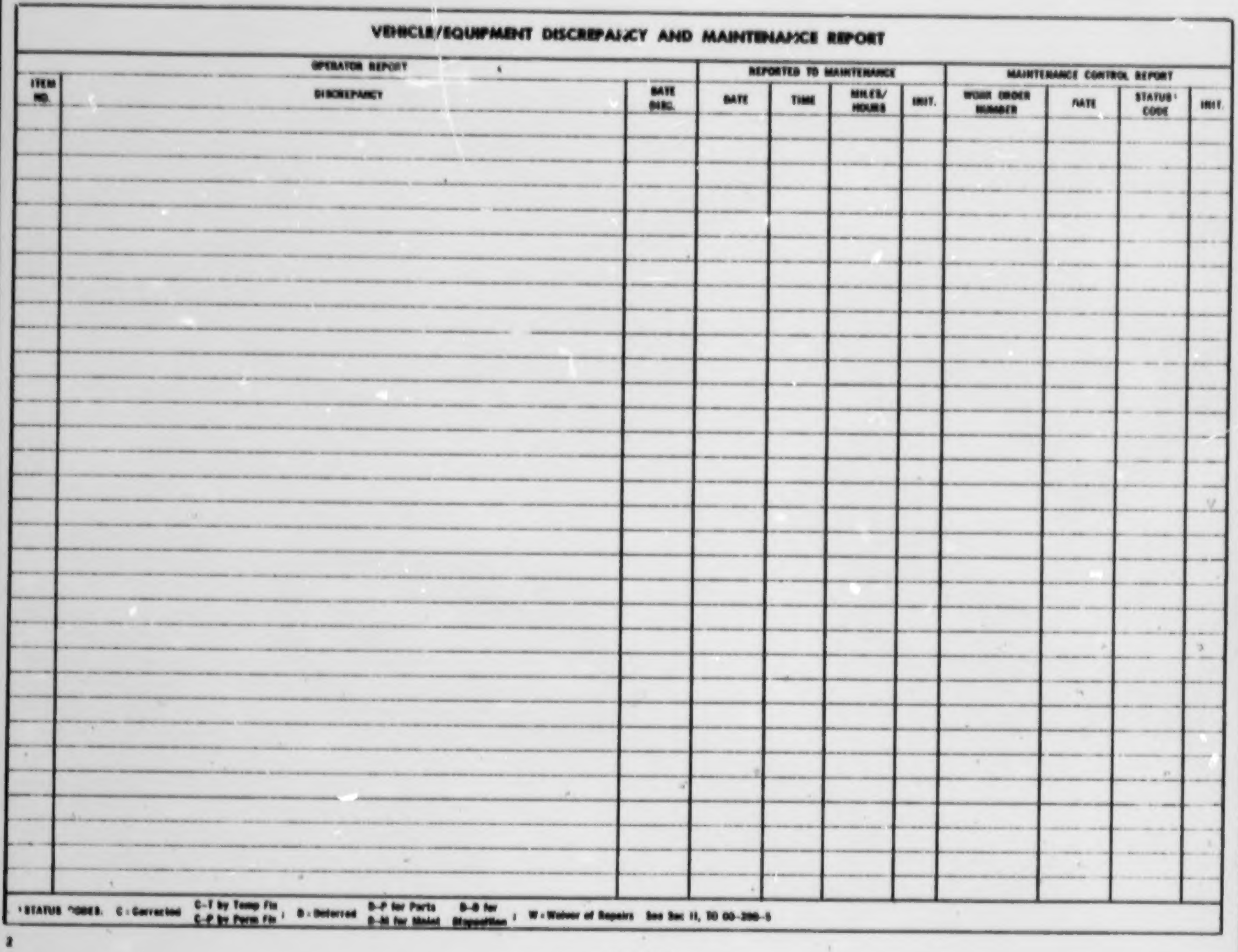
ITEMS TO BE CHECKED

1. **LUBRICATING OIL LEVELS** (engine/trans./priming pump)
2. **COOLANT, FUEL, AND HYDRAULIC LEVELS**
3. **FOR LEAKS** (oil, fuel, coolant, hydraulic, air, exhaust, etc.)
4. **CONDITION OF ALL DRIVE BELTS** (visual only)
5. **TIRES, WHEELS AND LUG BOLTS FOR TIGHTNESS, PRESSURE AND DAMAGE**
6. **BATTERIES** (front and rear) **FOR FLUID LEVEL, DAMAGE, CLEANLINESS AND SECURITY**
7. **CLEANLINESS, DAMAGE, MISSING ITEMS** (all interior and exterior items)
8. **LUBE/OIL CHANGE**
9. **BRAKES, CLUTCHES** (Operation), **AIR TANKS** (Drain), **OPERATE PARKING BRAKE**
10. **STEERING, SPRINGS & SHACKLES FOR OPERATION & DAMAGE**
11. **SAFETY DEVICES** (warning lights, buzzers, fire extinguishers, seat belts)
12. **OPERATION OF ALL LIGHTS, SIRENS, RADIO, HORNS, MIRRORS**
13. **WIRING/CIRCUIT BREAKERS** (visual only)
14. **SPECIAL EQUIPMENT** (axe, first aid kit, breathing apparatus, ladders, p.a. speakers, hydrant wrench, portable electric lanterns, etc.)
15. **FIREFIGHTING SYSTEM FOR CORROSION/DAMAGE AND FOAM/WATER LEVELS** (include booster tank)
16. **ON/OFF BASE GRID MAPS/STATE MAPS**
17. **HEATER/DEFROSTER**
18. **WINDSHIELD/WIPER/WASHERS** (condition and operation)
19. **INSTRUMENTS AND GAUGES** (during operation)

OPERATOR SIGNATURE	DAY
	1
	2
	3
	4
	5
	6
	7
	8
	9
	10
	11
	12
	13
	14
	15
	16
	17
	18
	19
	20
	21
	22

AFTO FORM JAN 74 **434** PREVIOUS EDITION IS OBSOLETE. 1

Figure 2-7. AFTO Form 434 (front).



VEHICLE/EQUIPMENT DISCREPANCY AND MAINTENANCE REPORT

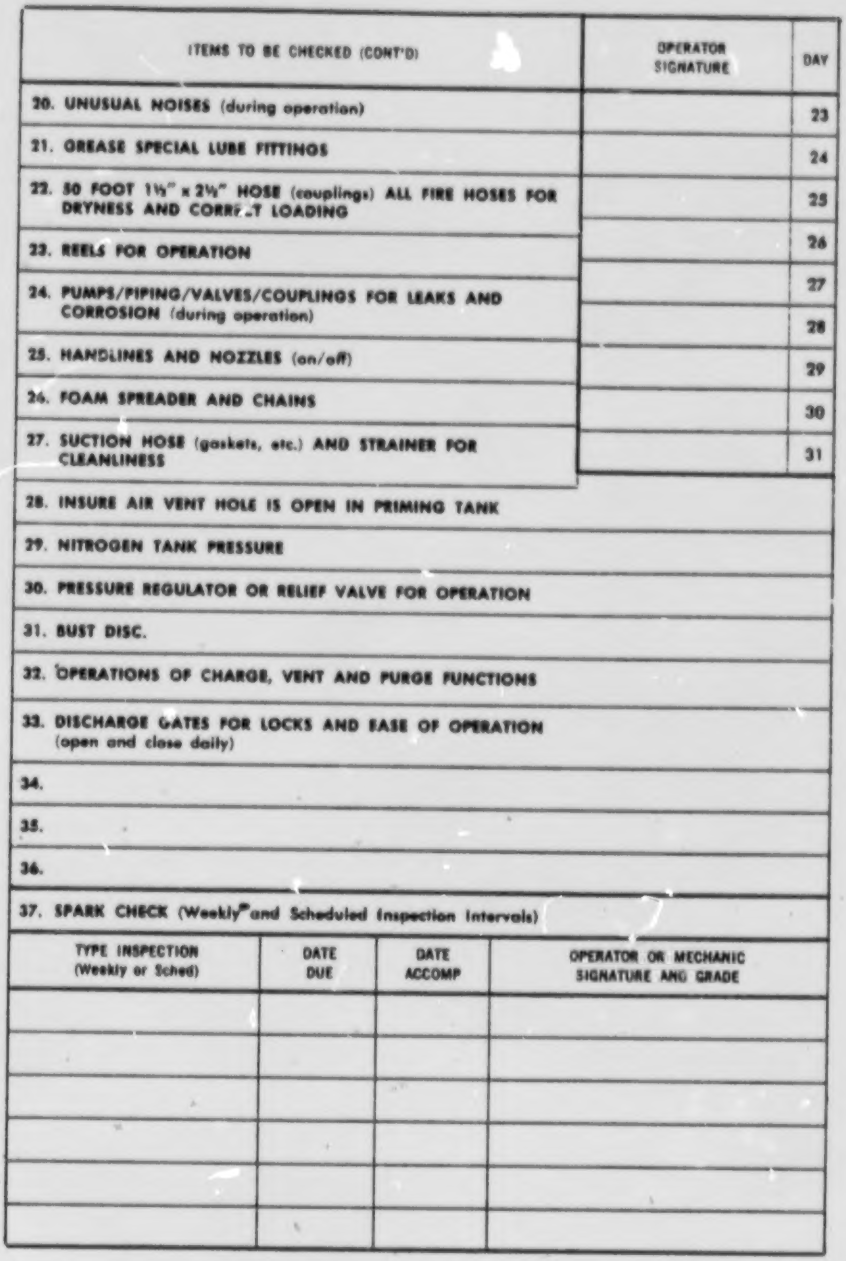
OPERATOR REPORT			REPORTED TO MAINTENANCE				MAINTENANCE CONTROL REPORT			
ITEM NO.	DISCREPANCY	DATE DISC.	DATE	TIME	MILES/ HOURS	INIT.	WORK ORDER NUMBER	DATE	STATUS¹ CODE	INIT.

¹STATUS CODES. C = Corrected C-T by Temp Fix C-P by Perm Fix ; D = Deferred D-P for Parts D-M for Maint D-D for Disposition ; W = Waiver of Repairs See Sec II, TO 00-200-5

2

(INSIDE)

Figure 2-8. AFTO Form 434 (inside).



ITEMS TO BE CHECKED (CONT'D)
20. UNUSUAL NOISES (during operation)
21. GREASE SPECIAL LUBE FITTINGS
22. 50 FOOT 1½" x 2½" HOSE (couplings) **ALL FIRE HOSES FOR DRYNESS AND CORRECT LOADING**
23. REELS FOR OPERATION
24. PUMPS/PIPING/VALVES/COUPLINGS FOR LEAKS AND CORROSION (during operation)
25. HANDLINES AND NOZZLES (on/off)
26. FOAM SPREADER AND CHAINS
27. SUCTION HOSE (gaskets, etc.) **AND STRAINER FOR CLEANLINESS**

OPERATOR SIGNATURE	DAY
	23
	24
	25
	26
	27
	28
	29
	30
	31

28. INSURE AIR VENT HOLE IS OPEN IN PRIMING TANK	
29. NITROGEN TANK PRESSURE	
30. PRESSURE REGULATOR OR RELIEF VALVE FOR OPERATION	
31. BUST DISC.	
32. OPERATIONS OF CHARGE, VENT AND PURGE FUNCTIONS	
33. DISCHARGE GATES FOR LOCKS AND EASE OF OPERATION (open and close daily)	
34.	
35.	
36.	

37. SPARK CHECK (Weekly* and Scheduled Inspection Intervals)

TYPE INSPECTION (Weekly or Sched)	DATE DUE	DATE ACCOMP	OPERATOR OR MECHANIC SIGNATURE AND GRADE

3

☆ U.S. GOVERNMENT PRINTING OFFICE: 1974— 757-167

Figure 2-9. AFTO Form 434 (back).

Exercises (829):

1. When is vehicle inspection guide NOT required on all active vehicles?

2. Who insures that all applicable entries from the previous inspection guide are transcribed to the new form the first of each month?

3. Instructions for proper maintenance of the operator's inspection guide and trouble report are found in what TO?

4. When checking out the chief's pickup which form should you use?

5. The AFTO Form 433 is used for inspecting what vehicles?

6. While inspecting an F-6, you notice that the guide you are using is an AFTO Form 434. The top of the form has been covered with dirt and you cannot make out the vehicles listed. Are you using the correct form? If not, what form should you use?

830. Name items to be checked during the daily inspection of firefighting vehicle and state actions to be taken.

Daily Inspection. As a driver, you are charged with the following inspection and remedial services when you start your tour of duty. Check the fuel gage reading; if the indicator shows less than three-quarters full, refill the fuel tank. You may find it advisable to "dip" the fuel tank to be sure of the full level; fuel gages have been known to be wrong — don't take chances. When dipping a tank be sure to use a nonsparking device and secure it so you don't drop it into the tank. Check the oil level with the dipstick and add oil to bring the level to the full mark when necessary. Check the coolant level in the radiator and refill if it is below the correct level or not plainly visible from the fill cap opening. When the cooling system is protected with an antifreeze solution, warm up the engine and test the concentration with a hydrometer. If necessary, add antifreeze to protect the system against the lowest temperatures expected. Inspect all hose connections and, if any are defective, have them replaced. Fuel, oil, water, and drive belts should be checked first to ensure that your vehicle is in readiness in the event of an emergency prior to complete daily inspection.

Engine. The engine and its related parts require considerable attention during a daily inspection. The engine must be started and running for some of the following checks. Examine the exterior of the engine and the accessories closely for indications of fuel, oil, or coolant leaks. Trace all signs of leaks to their sources and have the necessary repairs made. Examine the starter and generator mounting bolts and have them tightened if they are loose. Check the fan belt alignment and tension and observe for any unusual wear. Have the belts adjusted or replaced if necessary. Inspect the ignition system for loose connections of wires.

Chassis. You should examine the vehicle chassis in general from the front to the rear of the vehicle, especially the underside. Check the footbrake and clutch pedal for travel. The inspection of the body involves the safety of your fellow firefighters. You should check the handrails, rear platform, and running-board brackets carefully for security. If they are loose, weak, or defective, have them repaired or replaced immediately.

Pump. The fire pumps and accessories require considerable inspection and maintenance attention. Many of the checks require that the pump be in operation. All drain valves in the pump system should be opened to test their operation; then they should be closed to prevent loss of pressure and capacity during operation and to enable the pump to draft water immediately when required. You should check all discharge gates for freedom of movement. If gates operate with difficulty, you should lubricate them by dusting the cylinders or sphere with graphite. Then open and close them repeadly until they operate freely. Check the operation of the suction inlet and discharge outlet caps, since they must be removed without delay when the pump is to be used. You should inspect these caps for dirty threads and sticking gaskets which frequently require cleaning and replacement. Examine the suction hose for general condition and obstructions. If any obstructions are found, remove them and notify the officer in charge immediately. Check to be sure that the relief valve is in the proper position.

Tanks. You should see that the tanks contain agent to the proper levels and that the filter screen, which is visible from the deck opening, is in place and secure. You should check the tank suction valve for ease of operation and lubricate and/or adjust the drain and discharge valves if you see any malfunction in them. You must inventory all miscellaneous equipment daily and check to be sure that it is properly placed in and secured to the vehicle.

Batteries. You should measure the specific gravity of each battery cell with a hydrometer. If the specific gravity reading drops below 1.225 in any cell, you should have the battery recharged or replaced. In subzero temperatures, you must not allow the specific gravity to fall below 1.250. If you anticipate subzero temperatures, you will find that it is normally advisable to have the generator set for a higher charging rate.

Tires. Tires should be checked daily with an accurate air pressure gage to make sure that the correct pressure is in each tire, and while you're at it, check the lugs for tightness. Foreign objects such as nails and glass may be jammed into the tires during road travel. These must be carefully removed from the tires and an examination made as to the depth of penetration. You must be very sure that there are no air leaks from the tire in the area from which the object is removed.

Lights. You must test all lights mounted on the vehicle, including the emergency lights, spotlights, parking lights, and driving lights, both high and low beams. Replace dimmer switches if defective. Inspect all light wiring for loose connections and/or damage.

Exercises (830):

1. The four items to be inspected just during daily inspections are?

2. If the handrails, rear platform, or running board brackets are found to be loose, weak, or defective, what action should be taken?

3. What position is the relief valve stored in?

4. What should the tank suction valve be inspected for?

5. If the specific gravity drops below ______ in any cell, the battery should be recharged or replaced.

6. What instrument is used to check tire pressure?

831. Name the types of vehicle inspections and state the purpose of each.

Vehicle Inspections. When a pilot starts receiving instructions on flying, one of the first safety rules stressed is, "Watch your instruments." This includes showing the altitude of the aircraft in flight, as well as the instruments informing the pilot how the engine is operating. This rule also applies to any vehicle operator. The operation inspection explains why the instruments should be read at frequent intervals.

Before-operation inspections. The before-operation inspection assures you that your vehicle is ready for operation when you need it. You check the fuel, oil, and coolant level, adding if any is needed. Start the vehicle. A glance at the oil pressure gage indicates sufficient pressure. But almost immediately after starting, the oil pressure starts to drop slowly. A leak may be the cause. Low oil pressure may be caused by oil which is too light or too hot, an oil pump screen which is clogged, an improperly operating oil pump, or any one of many other reasons which may be common to a given engine. Any malfunction must be corrected. Make certain that all equipment is ready for use and in its proper position. In short, this inspection makes sure your vehicle is ready to respond to any emergency.

During-operation inspections. Instruments are used to let you know how the engine is operating. Without these instruments, engine performance would be largely guesswork. It need not require much of your time to read the instruments. A passing glance across the surface of the instrument panel will give you the necessary information you need. You should develop the habit of glancing at the instruments while driving. You will be able to quickly note danger readings on the instruments and take corrective action.

A high engine temperature reading can be caused by a number of things. Among them are a leak in the coolant system, a fan belt which is slipping or broken, ignition out of time, a defective water pump, or an engine shutter (if any) which is not operating correctly.

The ammeter shows the amount of electrical current being taken from or going into the battery. If a lower-than-normal current is noted and the battery does not have a full charge, the battery terminals may be corroded or the cables may have worked loose, the voltage regulator may not be operating correctly, or the generator or alternator may be defective. A slight discharge reading could mean a more serious condition requiring attention. However, if the ammeter shows a high discharge rate, a completely defective generator or a broken fan belt is possibly the reason. When the ammeter shows a high discharge rate, the vehicle should be brought to a halt immediately and the engine stopped. The trouble should be determined and corrected before the vehicle is operated again.

When the temperature gage reads slightly above normal and the ammeter reads slightly below normal, this condition indicates that the fan belt is not at the recommended tension. When operating under conditions calling for more electrical equipment than usual (night, winter, fog, etc.), the ammeter should still register in the CHARGE position. If it shows discharge, the lesser important items of electrical equipment should be turned off until the reason for the low reading is found and corrected.

Unusual noises of operation should be noted and the specific area determined, if possible, for later investigation. There are a great number of noises associated with the different moving mechanical components of a vehicle. Some of these noises are characteristic of certain parts of conditions—like a knock or loose bearings on a crankshaft, the tapping noise of loose valve tappets, or the squeal of dry bearings when they first begin to make noice and then develop into a grinding as they become loose from lack of lubrication.

It takes time and experience to be able to pinpoint a developing malfunction; however, by studying the technical orders concerning the vehicle and knowing the parts and the ways in which they can cause mechanical failure, you will have gone a lone way in keeping your vehicle in top operational condition.

After-Operation Inspections. Basically, the after-operation inspection is the same as the before-operation inspection. It is your assurance that your vehicle will be ready to respond to any emergency when it is called upon again. The fuel, oil, and coolant level are checked and refilled when necessary. The vehicle is cleaned and all parts are checked for damage or wear. All equipment is checked for condition and position. The equipment hose is replaced with dry sections, the water tank is refilled, and the foam tank is topped off if needed. Anything that is needed to put your vehicle into operating condition, should be done as soon as possible. A run is never completed until you can say that your vehicle is back in service.

Exercise (831):

1. What are the three types of operational inspections? What is the purpose of each type?

832. Determine entries to be made on front and back pages of inspection forms.

NOTE: The following instructions are applicable to all the inspection guide forms identified in objective 829 (figs. 2-1 through 2-9). The forms are described in sections as heading information section (top front page), inspection guide and operator signature section including spark check (front and back page), and the discrepancy and maintenance record section (center page).

Heading Information Section. The Vehicle Control Officer is responsible for initiation and issue of forms for each vehicle/equipment item on the first use day of the month. The assigned operator who performs the daily inspection on that day is responsible (1) to close out the previous month's form by carrying forward required entries according to instructions in the following paragraphs and (2) to return the old form to the Vehicle Control Officer for file and disposition. The new form will be issued with the heading information section completed as follows:

Date. Date (Mo/Yr), enter the month and year for which the form is effective, e.g., Jan 74 or March 74. Months with more than five letters should be abbreviated. Do not use numerics to indicate month (1/74) or Julian dates.

Vehicle Type. Enter the vehicle/equipment type designator. If type designator is not applicable or commonly recognized, the common name or nomenclature may be used in lieu of or in addition to the type.

Registration No. (number). Enter the registration number assigned to the vehicle/equipment item. If not applicable, use serial number or local identifier used for work order purposes.

Using Organization, Location, Phone No. (number). Enter organization identifier, station location and area if desired, and telephone number of the organization to which the vehicle is assigned for use.

Vehicle Control Officer, Name, Grade, Phone Number. Normally, this is the designated vehicle control officer for the using organization identified above.

Inspection Guide and Operator Signature Section. The inspection guide, "Items to be Checked", is listed by number down the left side of the front page and continued on the back page. The numbered blank lines are intended for local use to add items. This is especially useful when adapting one of the forms to a peculiar equipment item. In this instance only, standard listed "items to be checked" that are totally in-applicable to the peculiar equipment may be lined out. Normally items to be added or deleted (lined out) will be coordinated between the Vehicle Control Officer and maintenance activities.

Each listed "item to be checked" is inspected or serviced during each daily inspection. The operator should not make any entry, such as checkmark or initials on the item listing lines, to avoid mutilating the form during the month. The operator's signature opposite the day of the month in right margin column signifies satisfactory completion of all items, except when a discrepancy is entered by item number and date discovered on the center page.

Spark Check (weekly and scheduled inspection intervals) is documented under the last "items to be checked." The type inspection (weekly) and due date entry is always carried forward when the new monthly form is initiated and the spark check is applicable. This section may be voided if the particular vehicle/equipment item is determined not to be subject to the spark check requirement. The weekly spark-check due date is checked during each daily inspection. On the date due, the operator will accomplish the inspection and, if satisfactory, enter date accomplished, signature, and grade. On the next line, enter type inspection (weekly) and next date due computed as 7 calendar days subsequent to date accomplished. If the due date falls on a vehicle non-use day, the spark check is accomplished during the next daily inspection and prior to use in refueling or concurrent refueling operations. If a scheduled inspection is accomplished during the month, the maintenance supervisor or inspector will line out or erase "weekly" under type inspection next due and over write "scheduled"; enter date accomplished and signature stamp certifying completion of maintenance spark check. The next weekly date due will be computed and entered as indicated above.

Space is provided for operator signature opposite the numbered days of the month on the right margin of the front page and continued on the back page. Operator signature of first name, initial, and last name (opposite appropriate day of month) signifies satisfactory completion of inspections and/or servicing required for each listed "item to be checked" including spark check, except item numbers for which a discrepancy is being entered on the discrepancy and maintenance record (center page) or the operator determines that an appropriate entry is already being carried in a deferred or waiver status. Operator signature lines, opposite days of the month on which a daily inspection was not performed (non-use days), must be left blank or voided. The operator will normally certify completion of the daily inspection even though discrepancies discovered and reported to maintenance may cause the vehicle to be placed in out-of-commission status. If the vehicle is returned to service that day, the operator is only obligated to make a brief visual check as outlined in the paragraph for switch operators.

Exercises (832):

1. How should the date be entered in the date block on the front of a vehicle inspection form?

2. The entry in the Vehicle Type section for a P-8 should appear as ______.

3. If you are checking an item of equipment that does not have a registration number, what entry should be made in the registration number block?

4. When may standard listed items to be inspected be lined out?

5. How does an operator indicate that an item has been inspected?

6. When is the spark check section voided?

7. How should Jamie E. Sommers make the entry in the operator's signature space?

833. Determine entries to be made on center section of inspection forms.

Vehicle/Equipment Discrepancy and Maintenance Report Section (Center Page). This section is intended primarily for recording and indicating maintenance action and status resulting from operator discovered discrepancies. However, it will also be used by maintenance to record discrepancies discovered and *not* corrected during periods of maintenance (repair, inspection, and servicing). It is important that prior to entering a discrepancy, both maintenance personnel and operators make a careful check of the discrepancy list and their status to avoid duplicate reporting and processing of discrepancies. When a new monthly form is initiated, all open discrepancies (date under "Maintenance Control Report" part is blank) will be transcribed to the new form and enter "C/F" (Carried Forward) in the blank date space of the old form. Additional instructions for completing this part follows:

Item No. (number). Enter the item number of the inspection guide item against which a discrepancy is being reported. Leave blank when the discrepancy is not related to a numbered item.

Discrepancy. Enter a brief, specific description of the discrepancy. Normally, one line space should provide adequate description of the problem; however, when lengthy detailed explanation is necessary, a supplemental sheet may be attached to the form and work order for use by maintenance technicians.

Date DISC (Discovered). Enter date the discrepancy is discovered and entered. Use numeric/alpha combination to indicate day/month only. Abbreviate month to three letters, e.g., 10 Jan.

Date. Enter date, (e.g., 10 Jan), the discrepancy is reported to Maintenance Control.

Time. Enter clock time (4-digit, 24-hour clock) the discrepancy is reported to Maintenance Control.

Miles/Hours. Enter the current vehicle mileage or hour meter reading. Refer to Vehicle Ser-O-Plate (AF Form 1252) to determine appropriate entry of miles or hours.

Init (Initial). The individual completing the "Reported to Maintenance" part will initial in this space. Normally, this will be the individual who discovered and entered the discrepancy; however, it may be accomplished by Maintenance Control or other operations personnel when the "report to maintenance" is delayed for any reason.

Maintenance Control Report. Entries in this part will be made only by maintenance control personnel, the Maintenance Officer or Superintendent except as outlined before for closing out a form at the end of the month.

Exercises (833):

1. How is the date of a discrepancy discovered in August 1976 entered on an AFTO Form 433 for October 1976 if that discrepancy has not been corrected by 1 Oct 76?

2. If a discrepancy is discovered and is not against a specific item number, what entry is made in the Item No. block of the inspection form?

3. If you report a discrepancy to Maintenance Control at fifteen minutes after eight on the morning of 26 Nov 76, how would you make the entry in the time block in the center section of an AFTO Form 434?

4. What should you check to determine the entry to be made in the Miles/Hours block?

5. When do individuals other than the Maintenance Officer or Superintendent make entries in the Maintenance Control Report section of the inspection form?

5C1

CHAPTER 3

Structural Vehicle Pump Operations

MILLIONS OF DOLLARS have been spent to provide structural firefighting equipment for the Air Force. As a taxpayer, you are, of course, interested in how your money is used. You are doubly interested, as a firefighter, in what your money has purchased, since you will be required to use the equipment. So we will examine structural firefighting vehicles, more commonly and from now on in this course simply called pumpers.

At this point in your Air Force career, you are primarily interested in increasing your knowledge and skill as a firefighter. The greater your knowledge and skill as a firefighter, the better your chances are for promotion. Almost without exception, every firefighter is required to have an extensive knowledge of the design features, operating principles, and maintenance requirements of the different pumpers.

The knowledge you possess of these subjects must be equal to your skill in applying them. The safety of many people will depend upon your knowledge and skill as a pumper operator. Much of your knowledge and skill in the operation of pumpers will be in the area of safety. It will be your job to operate a pumper during an emergency situation and bring that operation to a safe, satisfactory completion.

To be sure, once a pumper has been used, there is much work to be done to make sure it is ready to respond to another call for help. The time spent preparing your pumper to respond to another call for help may extend into the early hours of the morning. But no matter what the hour of the day, if the pumper has been used, it must be made ready to respond again. Until this is done there is no rest for the pumper crew. Once the job is done, that good feeling of knowing you are ready to respond to any call for help is a satisfactory reward.

3-1. Pumper Mounted Components.

The various pumpers have several parts which are identical or which operate similarly to each other. There are also several items which are peculiar to only one of the pumpers. Your knowledge of these components will enable you to associate how and why the part is functioning as you operate it. The information will give you a better working knowledge, which in turn will increase your skill.

834. Determine the outputs of standard rated and earlier standard rated pumpers.

Pumpers used by the Air Force are divided into two groups: one group is made up of pumpers equipped with "standard" fire pumps. Standard rated fire pumps are designed to deliver their capacities according to the following specifications:

100% at 150 psi (pounds per square inch).
70% at 200 psi.
50% at 250 psi.

Among those used by the Air Force are the P-8, P-12, and 750A. These pumpers have design features which are similar to the commercial pumpers used in municipal departments. Normally they are used to combat airbase fires only.

The other group is made up of those pumpers equipped with fire pumps built to an "earlier standard" which required only the following lower capacities:

100% at 120 psi (pounds per square inch).
50% at 200 psi.
33.3% at 250 psi.

Pumpers equipped with earlier standard pumps usually meet the more rugged requirements for military type vehicles. Normally, these pumpers are used in combat areas, areas similar to those found in combat areas, or at bases which require protection for large areas of natural cover. The 530-series pumpers fall into this class.

Exercises (834):

1. A 1000 gpm standard rated pumper will deliver ______ gpm at 200 psi.

2. At 250 psi, a 500 gpm standard rated pumper will deliver ______ gpm.

3. At what pressure will a standard rated 750 gpm pumper have to operate to deliver a maximum of 375 gpm?

510

4. An earlier standard rated 500 gpm pumper will deliver 250 gpm at ______ psi.

835. State the operating principles of centrifugal fire pumps.

The Centrifugal Fire Pump. The engine itself is, of course, the most important part of the apparatus. Since the engine is the familiar internal combustion engine, we will not go into detail about it. In addition to furnishing mobility to the apparatus, it is the power source for the fire pump—the piece of equipment second in importance only to the engine. The fire pump, however, is a different matter, for the mechanical nature and general operating principles of the fire pump are frequently misunderstood. We shall, therefore, give you a general description of the type of fire pump now being used by the Air Force—the centrifugal type. Vehicles equipped with other type pumps used for firefighting are, as far as the Air Force is concerned, obsolete and will not be considered in this course.

Since this type fire pump is common on both structural and crash-rescue firefighting vehicles, we shall go into some detail here so that when you encounter it in the future you will be familiar with its operating principles. The principal differences between the pumps used for crash and those for structural firefighting are the volume and pressure. The operation of each is basically similar. Since the centrifugal pump is not a positive displacement type, there is no set amount of water discharged for each revolution of the fire pump. Therefore, before a draft can be successfully effected, a centrifugal fire pump will require priming (the filling of the fire pump with water). This is done by means of a priming device mounted on the fire pump. The operating principle of the centrifugal fire pump is based upon the fact that a rapidly revolving disk tends to throw anything placed upon it toward the out edge. This action can be demonstrated by means of a filled pail of water swung in circles around and over the head. The centrifugal action tends to hold the water in the pail even when it is directly overhead. If a small hole were cut in the bottom of the pail, the stream of water forced from the hole would gain volume and velocity as the speed of swinging the pail increased.

The single-stage centrifugal fire pump consists of a single disklike impeller mounted on a shaft within the pump housing. In figure 3-1, the impeller revolves counterclockwise. Water introduced through the intake (S) enters into the eye of the impeller (O). It is then picked up by curved vanes (V) as they revolve with the impeller, then thrown to the outer edge of the impeller by centrifugal action, and passed through openings (P) into the open space (I) in the casing or pump housing (C). Since the circumference of the impeller disk is greater at the outer edge of the bladelike vanes than it is at the inner edge, the outer edge of the impeller travels faster. In this manner, the velocity of water is increased as it passes through the impeller from the center outward. Likewise, as the rate of rotation of the impeller increases, the velocity with which the water is thrown from the

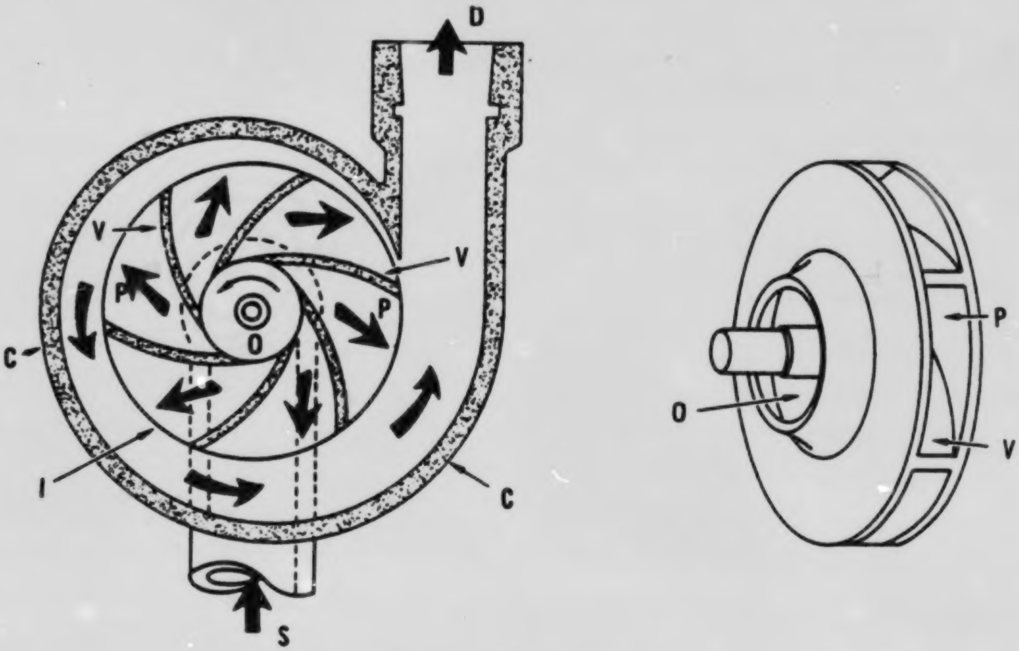


Figure 3-1. Centrifugal pump.

openings (P) into the open casing increases.

In most centrifugal fire pumps, the distance between the outer edge of the impeller and the wall of the casing increases as it approaches the discharge outlet (D), forming what is known as a volute. This gradually increasing space is necessary because the water is thrown from the impeller around the entire circumference. This means that the total quantity of water passing through the casing is increasingly greater toward the discharge outlet. The volute enables the pump to handle this increasing quantity of water while at the same time the speed of the water is not affected. In centrifugal fire pumps not using the volute principle, the flow of water is directed toward the discharge outlet by a series of stationary diffusion vanes fastened to the inner wall of the pump casing. The rotation of the impeller creates a speed in the water which is converted into pressure as it approaches the confining space of the discharge pipe.

In the centrifugal pump there are no valves or other blockades within the pump itself. A continuous waterway extends through the pump from the intake to the discharge outlets. Passageways through the impeller are frequently small, however, and are subject to clogging if foreign matter is permitted to enter the pump. Since such clogging of the impeller seriously affects the operation of the pump, care should be taken that the pump inlets and suction hose are properly screened in drafting.

Exercises (835):

1. What does a centrifugal pump require before it will draft?

2. A single stage centrifugal pump has how many impellers?

3. How is the velocity of the water within a centrifugal pump increased?

4. What FORMS THE VOLUTE IN A PUMP?

5. What purpose does the volute serve in a pump?

6. Name the valves located within the pump itself.

836. State the purpose and explain the operation of the transfer valve.

Transfer Valve. The transfer valve is a part of the two-stage fire pump. The single-stage pump has only one impeller within the fire pump and has no need for a transfer valve. The transfer valve, more commonly and from now on called the changeover valve, is used to change the operation of two-stage centrifugal fire pumps. Figure 3-2 illustrates the two operations, parallel and series (volume or pressure), of which the two-stage fire pump is capable. The words "parallel" and "volume" are used interchangeably as are the words "series" and "pressure" when describing the effect the changeover valve has on the fire pump output. A handwheel on the pump control panel is used to operate the changeover valve.

Water is able to enter the fire pump from several intake points, but for the sake of simplicity the intakes will be marked "A" in either parallel or series operation. Looking at figure 3-2, you get an inside view of a two-stage centrifugal fire pump which has the top half sliced off. Notice, as the water moves along the intake channel A in the parallel operation, it divides into two passageways. The water then enters the eyes of both the front and rear impellers C and D. The water is subjected to the centrifugal force of the impellers as they turn. The speed of the water is increased and it is sent out a common channel, B. Channel B is the discharge side of the fire pump to which all firehoses are connected. Take time now to study the parallel operation before starting in on the series operation.

By now you should have a clear picture of the parallel pump operation. Now take a look at the series operation position in figure 3-2. The changes you see have occurred as a result of turning the handwheel fully counterclockwise from its stored position. This action puts the fire pump into a series operation. The water first enters channel A as before, but the handwheel has turned the changeover valve so that water in the lower left channel A is stopped. The water can now enter only the eye of the front impeller C. The water is boosted to half the operating pressure by the first impeller and is then discharged from the front impeller C and flows through the crossover tube E. At this point the water does two things: (1) it flows into the eye of the rear impeller D and (2) part of the water starts to rush out channel A, thus causing the one-way check valve to swing closed. All water must now enter the eye of the front impeller. The water then flows out channel B to the fire pump discharge gates. Both impellers are mounted on the same shaft, consequently, each impeller must turn at the same speed. That is how half of the operating pressure is reached in the first (front) impeller.

Exercises (836):

1. A transfer valve is not used on what type centrifugal fire pump?

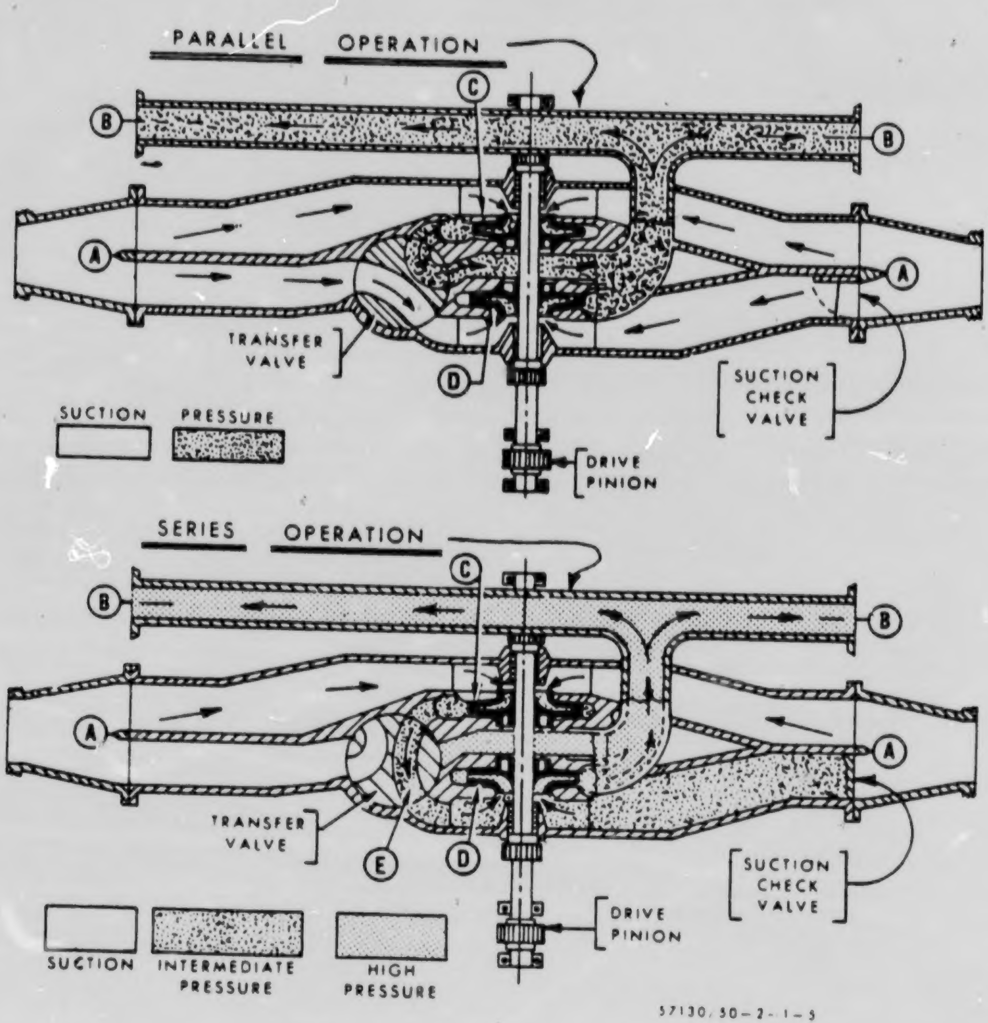

PARALLEL OPERATION
C
B
B
A
A
TRANSFER VALVE
D
SUCTION
PRESSURE
SUCTION CHECK VALVE
DRIVE PINION
SERIES OPERATION
C
B
B
A
A
TRANSFER VALVE
E
D
SUCTION
INTERMEDIATE PRESSURE
HIGH PRESSURE
SUCTION CHECK VALVE
DRIVE PINION
57130/50-2-1-5

Figure 3-2. Two-stage centrifugal pump operation.

2. What does the transfer valve do?

3. What is used to operate the transfer valve and where is it located?

4. When water is discharged from both impellers to a common channel from the pump, the pump is operating in what position?

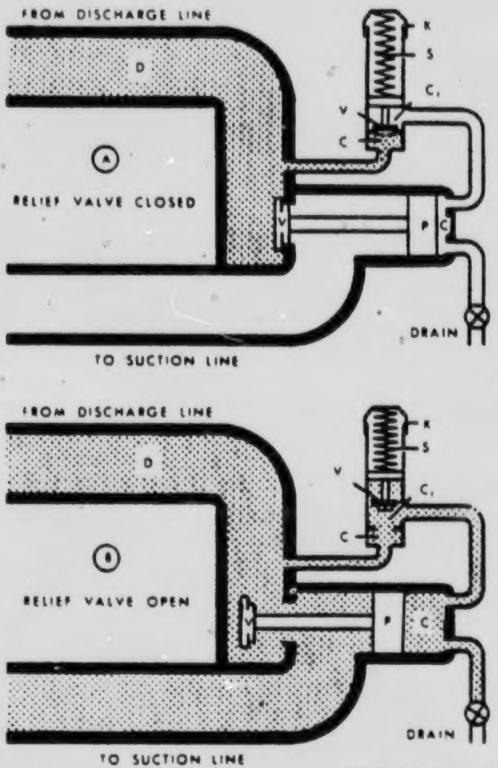
5. When changing from parallel operation to series operation, in which direction should the transfer valve handwheel be turned and how many turns?

6. What prevents water from escaping through the intake channel when the pump is operated in series and how is this device operated?

7. When pumping for high pressures, the pump must be operated in _______ .

837. Cite facts about the function and operation of the relief valve.

Automatic Relief Valve. The automatic relief valve, shown in figure 3-3, opens automatically during excessive surges of pressure from the discharge side of the pump. The valve can be adjusted beforehand to the maximum pressure desirable for a particular operation. There are several types of automatic re-



57130 50-2-1-6

Figure 3-3. Relief valve.

lief valves in general use, but all of them operate on the same general principle. Briefly, the comparatively complicated automatic relief valve consists of an arrangement of springs and simpler valves such that when the pressure on the discharge side exceeds the pressure for which the controlling spring is set, the valve opens, permitting water to flow back into the intake side of the fire pump. This relieves the excessive discharge pressure. When the pressure drops below the setting of the spring, the valve closes, and the flow from the discharge to the intake side of the fire pump stops.

In a typical arrangement of an automatic relief valve, water from the discharge side of the pump holds closed a valve (V), blocking the passage to the intake chamber in part A of figure 3-3. Just above this valve in the diagram is the opening of the control line. Water under pressure from the discharge side is prevented from flowing through the control line by a valve (V) held closed by the tension of its spring (S). The resistance of the valve (V) to the water pressure may be changed by turning the screw control cap (K). Figure 3-3, part B, shows what happens when the discharge pressure exceeds the pressure at which the spring tension is set. The valve (V) opens, permitting water to flow into the chamber (C^1) and through the connecting tube ~~to~~ the chamber (C) of the relief valve proper.

When the valve (V) is opened, the unit pressure acting upon the piston (P) in the chamber (C) is equal to the unit pressure acting upon the valve (V) from the discharge chamber (D). However, the total area of the piston (P) (on a common shaft with the valve) is greater than the area of the valve (V) so that the total force on the piston tending to hold it closed. Consequently, the valve opens, permitting water to flow from the discharge chamber (D) into the suction line. When the pump pressure drops below the pressure on the spring, the valve (V) closes, and the water beyond it in the control line empties out through the drain opening. The pump pressure then acting upon the valve (V) in the discharge chamber closes it, stopping the flow from the discharge side to the intake side of the pump.

Exercises (837):

1. When does the automatic relief valve open?

2. What causes the relief valve to open?

3. How is the resistance of the pressure valve in a relief valve changed?

4. When the relief valve opens, where does the water from the discharge line go?

5. Once the discharge pressure falls below the relief valve setting, what prevents the water from the discharge side of the pump from continuing to pass to the intake side of the pump?

3-2. The A/S32P-12 Pumper

The Air Transportable Structural Fire Fighting Truck, Type A/S32P-12 (hereafter referred to as the P-12) is designed to provide quick response for supression and extinguishment of real property and material fires. The vehicle is able to operate on paved surface and on unimproved roads as required to accomplish the firefighting mission. A controlled water pressure at a rate of 750 gpm is provided by the vehicle from a hydrant, a static water supply, or the self-contained water tank in the vehicle.

The vehicle is air transportable by C-130 aircraft. Tie-down points are provided at appropriate points on the vehicle for securing it to the floor of the aircraft cargo compartment. Each tie-down point is appropriately stenciled for ready identification.

The vehicle consists of a gasoline-engine powered

4x2 chassis, designed to transport and deliver water or foam solutions in various structural firefighting situations. The single gasoline engine provides power for operation of the drive train and running gear as well as the firefighting pump. A 12 volt electrical system is provided for operation of electrical equipment and accessories.

The Model P73MW vehicle is the same as the Model P73M, except for the addition of the winterization system to maintain the vehicle in a stand-by ready condition in winter climates. The Model P73MW is operational at temperatures as low as -40°F. The Model P73M is equipped to operate at temperatures as low as -20°F.

838. Give basic facts about pertinent characteristics of the P-12 pumper.

Cab. The tilt type cab is hinged at the front end and will tilt forward approximately 45°, providing access to the engine and fromt chassis components. A double lock is installed at the rear of the cab to prevent accidental tilt. An access plate is provided behind the right seat back to allow the engine oil and coolant levels to be checked without tilting the cab.

The cab provides comfortable seating facilities for a crew of up to three and provides a complete complement of controls and instruments as necessary to effectively control and monitor the performance of the vehicle when driving. Seat belts are provided for all crew members.

A fresh air cab heater is provided for use in cooler climates. The heater has adjustable doors on its front and sides to establish comfortable air circulation throughout the cab. The amount of heat can be regulated by a two-speed heater fan and also by controlling the amount of fresh air passing through the heater.

The windshield defroster is integrated with the cab heater and also has controls to regulate the temperature and volume of air used for defrosting.

Windshield and Wipers. All windows are made of safety plate glass. Two independent electric windshield wipers are provided, one for each piece of the two piece windshield. Each wiper has its own motor and related components. Both wipers are controlled by a single two-speed switch on the dash panel.

Windshield Washers. Windshield washers are provided to aid in keeping the windshield clear of dust, soot, insect debris, etc. The washers are activated by a foot pump on the floor of the cab. Both sections of the windshield are washed simultaneously by activating the foot pump and the wiper switch. The reservoir for the washer fluid is mounted inside the cab for easy access when adding fluids.

Buzzer. A 12-volt buzzer is installed in the cab, and a weather-proof push button switch is located on the left rear hand rail support for signaling from the rear platform to the cab.

Chassis. The chassis is a four-wheel, two-wheel drive (4x2) commercial Ford chassis with dual rear tires. The front axle is a straight "I" beam style with double acting shock absorbers. The rear axle is a single reduction type with convential differential. Both axles have leaf springs with spring stops to cushion contact of springs with the frame. The chassis was modified for mounting of major assemblies and tie down and towing attachments required for a firefighting vehicle.

Body. The body, which is separated from the cab, includes the fire pump housing, LH and RH pump panels, hose bed, side and rear platforms, toe steps, rear wheel housing, handrails, equipment cabinets, and mounting brackets for mounting the auxiliary firefighting equipment.

Engine. The engine is V-8 gasoline fueled design, 391 cubic inch displacement, rated at 199 net horsepower at 3800 rpm. The engine is equipped with an oil bath air cleaner, manual choke, positive crankcase ventilation, full flow oil filter and mechanical fuel pump. The engine is cooled by a pressurized coolant system, regulated by a thermostat.

Auxiliary Equipment. An auxiliary heat exchanger permits delivery of water from the fire pump for cooling the engine liquid coolant. The flow of water from the fire pump to the heat exchanger is controlled by a manually operated valve located on the left-hand pump operator's panel. Readily accessible drain cocks are installed to completely drain the system. These drain cocks will remain closed during operating procedures. An auxiliary electric fuel pump is installed for use in the event of mechanical fuel pump failure or vapor lock conditions. The control switch for the auxiliary electric fuel pump is located on the cab's dash panel.

Transmission. The transmission is fully automatic, hydraulically operated with four forward and one reverse gear. The transmission assembly consists of a torque converter, planetary gear train, and a hydraulic control system. The transmission fluid is cooled by two methods: by the engine radiator when driving and by the fire fighting water when pumping. Transmission fluid flows through a heat exchanger mounted in the bottom of the engine radiator, through an auxiliary heat exchanger mounted on the frame and then back to the transmission. The radiator heat exchange provides primary cooling whenever the engine is running. The auxiliary heat exchanger provides additional cooling whenever the fire pump is in operation. This flow of transmission fluid occurs automatically whenever the transmission is in operation.

The transmission is automatically locked into the high gear when pumping. This lockup in high gear (1 to 1 ratio) is performed by a valve mounted on the left side of the transmission which is actuated (opened) when the pump shift control is placed in the pump position. The main transmission fluid pressure is then directed through the valve to the governor port to boost the pressure, thus, holding the transmission in high gear.

Exercises (838):

1. How are the oil and coolant levels checked on the P-12 without tilting the cab?

2. How are the windshield washers activated?

3. What is the buzzer on the left rear handrail support for?

4. What type of chassis is the P-12 mounted upon?

5. What is the rated horsepower of the P-12 and its piston displacement?

6. The auxiliary heat exchanger on the P-12 serves what function?

7. How is the transmission fluid cooled?

8. In what gear does the P-12 pump?

9. What happens within the transmission when the pump shift control is placed in the pump position?

839. Give pertinent facts about the construction and operation of the firefighting system of the P-12.

Fire Pump. The pump is a two-stage centrifugal (parallel series) type with volute discharges, designed for operation from either draft, hydrant, or the water tank.

A manual shift is used to engage the pump to acquire power from the engine. When the pump is engaged, the impellers within the pump force water through diverging passages, converting high velocity of the water into pressure.

A manual transfer valve in the pump changes the pump action from parallel (volume) to series (pressure) operation. When the transfer valve is in the VOLUME position, each impeller operates as a separate single-stage pump, working in parallel. Each impeller accepts water from the pump intake and discharges into the pump outlet in high volume. When the transfer valve is in the PRESSURE position, the impellers operate in series. Discharge from the first stage is directed into the suction of the second stage, reducing water volume by one-half and doubling pressure.

Fire pump housing. The top surface of the pump housing is easily removable for lifting out the pump without removing more than the pump suction and discharge fittings. An easily removable panel, fastened with quick-disconnects, is provided to allow maintenance personnel access to the pump compartment without removing hose reels and related major components. The fire pump housing is fully enclosed and insulated to provide for cold weather operation to -20° F and/or allow ready field modification for -40° F operation.

Left-Hand Pump Operator's Panel. The left-hand pump operator's panel is located on the left side of the vehicle. Pump pressure and suction gages are connected to the pump manifolds. Six 2½-inch diameter discharge gages are connected to the hose line side of each of the four discharge valves, and to each of the two preconnects. The gages are of the single Bourdon type, flush mounted. Individual steady valves eliminate pressure fluctuations. The panel is illuminated for night operation.

Agent Tanks. The agent tanks can be readily removed from the vehicle. Removable top covers allow access for cleaning and repair of internal tank portions. The top covers are sealed to prevent agent leakage. Baffle partitions are installed in the tanks to prevent longitudinal surges or side-sway while the vehicle is maneuvering with the tanks filled or partially filled to any level. Baffles in the foam liquid tank prevent excessive foaming of the liquid. Agent tanks are insulated to provide for cold weather operation to -20° F and/or allow ready field modification for -40° F operation.

Water tank. The water tank capacity is 300 gallons. It has a nonsplash overflow which is vented below the vehicle frame and directed towards the ground. The tank is provided with a top fill with a gasket and hinged cover. It is so designed that a 2½-inch hose with a coupling can be placed in the opening and the tank filled without the hose being held by the operator. The fill opening includes a 10-mesh removable strainer to prevent entry of foreign matter into the tank during fill operation. The tank can also be filled by pressure through the fire pump.

The water tank discharge (pump suction) line is provided with a quick-opening shut off valve, and a drain valve at the lowest point in the line to provide complete drainage. Valve controls are operable from the pump control panel. A check valve prevents entry of foam solution into the water tank.

Foam tank. The foam liquid tank capacity is 55 gallons. It is provided with a splash proof vent directed toward the ground. The tank has a filler neck, incorporating a removable strainer and a hardened steel puncturing device, so that the foam liquid tank can be easily filled from a standard 5-gallon foam liquid container. The filler neck is located in the left forward corner of the tank and is equipped with a gasket-type cover. The tank drain and the discharge are at the lowest area in the tank to provide for complete drainage. The drain valve is located immediately adjacent to the tank, minimizing the length of piping between the tank and valve. Valve controls are operable from the pump control panel.

Foam Proportioner. The foam proportioner is of the around-the-pump type. Foam liquids are inducted by venturi action into a line carrying a portion of the solution from the fire pump discharge. The foam liquid-water mixture is drawn into the pump intake and mixes with the main water flow. A metering valve in the foam liquid line leading into the venturi controls the amount of foam entering the venturi.

A quarter-turn ball valve is installed between the foam liquid tank and the metering valve, and another between the pump discharge and venturi. A check valve installed between the metering valve and venturi prevents flow of water into the foam liquid tank. The foam liquid metering regulates the proportioning of foam liquid to total solution flow. A graduated indicator shows the discharge percentage of foam. The indicator, metering shut off, and flushing controls are operable from the left hand pump operator's panel.

Booster Hose and Reels. A booster hose reel is mounted above the pump compartment on each side of the vehicle. Four 50-foot lengths of 1-inch inside diameter hose is installed on each reel. A 1-inch combination spray and stream handline nozzle is connected to the ends of the booster hoses. Nozzles are securely mounted in quick-release devices. A handcrank manual rewind is equipped with a friction brake payout to prevent the reels from turning because of backlash and pressure surges and to prevent overtravel.

Exercises (839):

1. What type of pump is used on the P-12?

2. How is the pump of the P-12 engaged?

3. Without modification, the P-12 pump housing is insulated for cold weather operation to what temperature?

4. How many discharge gages are mounted on the left-hand pump operator's panel and to what are they connected?

5. Why are baffle partitions installed in the agent tanks?

6. How may the water tank of the P-12 be filled?

7. How much foam does the P-12 foam tank hold?

8. What type of foam proportioner is employed on the P12?

9. How is water prevented from entering the foam tank and where is this device located?

10. What is the total amount of booster reel hose mounted on the P-12 and what size is it?

840. For given instances state important facts about the characteristics of the pressure computer on the P-12 and its use.

Pressure Computer. The pressure computer is used to calculate pump pressure for a given lay. The faceplate is divided into five groups: 1½-inch hose, 2½-inch hose, relay, master lines, and varying factors to consider in each lay. The upper thumb wheel controls all of the pressure readings appearing in the 1½-inch hose group, 2½-inch hose group, and relay. The lower thumb wheel controls all the pressure readings appearing in the master line group. The seven factors to consider in each lay are as follows:

Factor 1. When hose lay goes uphill for a vertical rise totaling 50 feet, then add 1 pound/2 foot rise, or 25 pounds must be added to the indicated pressure.

Factor 2. When hose lay is descending vertically 50 feet, decrease pump pressure 25 pounds.

Factor 3. Add 5 pounds of pump pressure for every story the nozzle is elevated above the ground.

Factor 4. On a double line of equal length and equal tip size, compute ONE LINE ONLY for proper pressure on both lines. Example: Double 500-foot lay, 2½-inch hose, 1 inch tips, and pump at 100 psi. The total gpm discharge will be 400 gallons.

NOTE: This factor also applies on equal double line lays for a wye. The friction loss in the supply line to the wye must be added to the pump pressure. See factor 6.

Factor 5. On an unequal line lay, assume a 550-foot and 450-foot lay of 2½-inch hose using ⅞-inch and

1-inch tips. Place the 1-inch tip on the short (450-foot) line and the smaller (⅞) tip on the long (550-foot) line only. Dial 450 feet in the "TOTAL HOSE LAY" window, read above the 1-inch tip and the indicated pressure is 95 psi. This will net a 50-pound nozzle pressure on the 1 inch tip and a 54-pound nozzle pressure on the ⅞-inch tip. This procedure is followed to prevent excessive pressure developing in the longer lay. This particular lay will discharge about 352 gpm.

Factor 6. A wye layout is actually two different lays in one. In all layouts, the gpm discharge of the nozzle, or in this case, two nozzles, is the most important factor. This is determined by the tip size and the pressure applied to the tips. In this case, it will be 50 pounds. Therefore, assume that there is a 500-foot lay, 2½-inch hose, to a 2½-inch x 2½-inch x 2½-inch wye and two 300-foot lays of 2½-inch hose from the wye with ¾-inch tips. That can be construed as being two separate lays composed of one single line and one double line. Dial 300 feet in the "TOTAL HOSE LAY" window and note the psi indicated in the window above the ¾-inch tip which is 2 pounds. To determine the pound friction loss in the supply line to the wye, find the total gpm discharge of a 1 inch tip. The friction loss per 100 feet of a 1-inch tip is 10 pounds. Therefore, the friction in the 500-foot lay is 50 pounds. Add the 50 pounds to the 62 pounds which totals 112 pounds pump psi. If a 2½-inch x 2½-inch wye is used, the friction loss on the supply line is based on the 2½-inch constants. Using two 1½-inch lines from the wye to two ½-inch tips, each discharging 50 gpm or a total of 100 gpm is equivalent to a ¾-inch tip used on a 2½-inch line which is 4 pounds friction loss per 100 feet. Therefore, the computer indicated 80 pounds from the wye, including nozzle pressure, and added to this will be 4 pounds per 100 feet or 20 pounds for a total psi on the pump of 100 pounds. The computer can be used to determine both the supply line and the wye lay. However, inasmuch as the nozzle pressure is computed into each indication appearing in the psi window, 50 pounds must be deducted from the final total. Otherwise, there will be 100 pounds nozzle pressure. If the total gpm discharge is under 100 gpm, the friction loss in the 2½-inch supply line will be negligible when the lay does not exceed 250 feet. If an up or downhill lay is involved, that must also be added or subtracted from the final pump psi.

Factor 7. Siamese Lay — Essentially a reverse wye lay. The Siamese lay is used when it is necessary to reduce the friction loss that would be present in the maximum pressure that a pump operator would allow the pump to develop. This would be 200 pounds on 1½-inch or 2½-inch double jacket, rubber-lined hose, even though the factor test on the new hose may be as high as 600 pounds. If a large volume of water has to be pumped a long distance through a single line, the pressure necessary to accomplish this may become excessive and would cause possible damage to pumps and hose and, in some cases, might exceed the pressure capacity of the pump. Therefore, a single 2½-inch lay, 750 feet long with a 1½-inch tip operating at 50 pounds nozzle pressure, would require 238 psi on the pump. However, by laying two lines 700 feet long from the pump to a 2½-inch wye and then one 50-feet length to a 1¼-inch tip, the pressure at the pump would only have to be 119 psi. This is exactly one-half the pressure needed for the single-line lay and the engine is being operated at a much lower rpm. For the computer to solve this problem, dial 700 feet in the "TOTAL HOSE LAY" window and read the indication appearing above the ⅞-inch tip or 106 pounds, because this tip discharges one-half that of a 1½-inch tip. The friction loss in the single line to the tip is 13 pounds. Add this to the 106 pounds for a total psi of 119 pounds.

Exercises (840):

1. The faceplate of the pressure computer is divided into how many groups, and what are they?

2. How many factors are there to consider in each hose lay?

3. How much pressure must be added for each foot of vertical rise for uphill lays?

4. On a double-line lay of equal length and equal tip size, how do you compute the pressure required?

5. What is the most important factor in determining pump pressure on a wye layout?

6. How would you have the computer solve the following problem? What would be the required psi for a lay of two 700-foot 2½-inch lines with a 2½-inch Siamese with 50 feet of 2½-inch hose from the Siamese to a 1¼-inch tip maintaining 50 psi at the tip?

841. Explain how to set up the P-12 cab for pump operation from a hydrant, the pump for operation from a hydrant, and cab breakdown for pump operation termination.

Mobile operation of the vehicle is in many ways very similar to a similarly equipped conventional vehicle. The vehicle is equipped with hydraulic power steering, power-assisted hydraulic brakes on all wheels, and a fully automatic transmission. Controls and instruments necessary for mobile operation are all grouped within easy reach of the driver's normal seated position.

Engine Starting Procedures. Engage the parking brake and place the transmission range selector lever into neutral (N) position. Pull the ignition switch full outward. (Ignition indicator light will illuminate.) Depress the throttle pedal halfway down; press and hold the starter switch until the engine starts.

If the engine does not readily start, pull engine choke control partially outward. Actuate the starter motor. When the engine starts and is operating smoothly, push the engine choke control fully in. Observe the ammeter to check the electrical system condition. Observe the engine oil pressure gage. Oil pressure indicated should be mid-range.

CAUTION: If the engine oil pressure is less than mid-range, STOP the engine to prevent damage caused by lack of lubrication.

Fire Pump. The fire pump is designed to operate at up to 200 psi net-pump pressure in the volume mode. The volume should be utilized at any net pump pressure under 150 psi. A word of caution. Do not operate the pump in excess of rate capacities and pressures. Damage to the fire pump may result.

Engaging Fire Pump (Disengaging Rear Axle) For In-Cab Procedures. Bring the vehicle to a complete stop. With engine running at idle, engage the parking brake, and place the transmission range selector lever into neutral (N) position. Engage the pump brake by pulling up the handle and twisting to lock. Shift the pump drive gear from the rear axle drive to the pump drive by pulling up the PUMP SHIFT handle. Twist the handle to lock into position. Unlock and release the pump brake and place the transmission range selector lever into drive (D) position. Place the transmission range-selector lever locking device over the lever to keep the lever from being moved.

Operating From Hydrant. Complete the in-cab procedures for pumping as outlined above. Make the necessary hose connections at hydrant and vehicle; open the hydrant and auxiliary suction valve if used. Open desired discharge valves and lock in position. Check for proper hose lay and top size. NOTE: If pressure is above 150 psi, change transfer valve to series/pressure operation. Transfer valve is normally stored in volume (fully clockwise) position.

Adjust the engine throttle gradually until desired pressure is attained. Adjust the pressure-relief valve as follows: (1) turn adjustment wheel counterclockwise until the pilot light is illuminated; (2) turn adjustment wheel clockwise until the pilot light is extinguished — the valve will now operate at the set pressure; and (3) set the relief valve at the appropriate position — it may be set as low as 50 psi.

CAUTION: If engine temperature exceeds 190 degrees F open auxiliary cooling valve.

When pumping in high ambient temperatures, open the access door atop the pump compartment for better air conculation.

NOTE: If a shutdown is required for changing hoses or for any other reasons, slow the engine to decrease water pressure to 30 psi and close the discharge valves. Periodically open a discharge valve to release heated water from the pump. This prevents overheating.

Shut down pump as follows:

(1) Throttle engine down.

(2) Close hydrant.

(3) Close discharge valves.

(4) Restore relief valve to clockwise position.

(5) If transfer valve was used return to volume setting.

(6) Close auxiliary cooling valve.

(7) If ambient temperature is below 32° F, drain fire pump system to prevent damage.

Perform cab breakdown procedures by reversing setup procedures.

Exercises (841):

1. If, after starting the P-12 engine, the oil pressure indicates at less than midrange, what action should you take and why?

2. How is the pump brake engaged?

3. In what position is the transmission range selector placed for pumping?

4. After making necessary hose connections at the hydrant and the vehicle, what is done before the desired discharge valves are opened and locked?

5. When should the transfer valve be changed to the series/pressure position?

6. How low may you set the relief valve?

7. Discharge valves should not be closed when the pressure exceeds _______ psi.

842. In cited instances state the required facts about operation of the P-12 from a draft and/or water tank, and foam operation.

Operating From Draft. Position the vehicle as near the water supply as possible and apply the parking brake.

Complete the in cab procedures for pumping as outlined in the preceding section.

Attach a hard suction hose to a pump suction inlet, and attach a strainer to the other end of the suction hose and submerge it in the water supply.

NOTE: If possible, submerge the strainer at least 2 feet below the surface of the water and keep the strainer off the bottom. Use every precaution to keep sand, leaves, or other foreign material away from the strainer to prevent restriction of flow.

Turn the transfer valve control wheel to the volume position.

Actuate the priming pump as follows: (1) Adjust the engine throttle to operate the engine at 1300 to 1500 rpm; and (2) Pull and hold pump-primer control handle until a steady stream of water is discharging from primer under vehicle or until the pump pressure gage indicates pressure.

NOTE: Water should enter the fire pump in 10 to 30 seconds of primer operation. If the pump does not discharge within this time lapse, do not continue to operate the primer pump. Stop and look for air leaks.

Open desired discharge valves and lock them in position.

Repeat procedural steps outlined in preceding section for hose layout, throttle adjustment, and relief-valve operation.

When pumping in high ambient temperatures, open the access door atop the pump compartment for better air circulation.

NOTE: If a shutdown is required for changing hoses or for any other reasons, slow the engine to decrease water pressure to 30 psi and close the discharge valves. Periodically open a discharge valve to release heated water from the pump. This prevents overheating.

Shut down the pump as described in the section on operation from a hydrant and perform cab breakdown procedures in the same manner.

NOTE: If salt water or water containing sand or other foreign matter has been pumped, operate the pump from a fresh water hydrant to flush the contaminants from the pump. Open the discharge valves, the discharge line-drain valves, and the pump drain valve and allow the water to drain from the pump.

Operating From Water Tank. Complete the in-cab procedures for pumping as outlined before. Open the water tank suction line valve, turn the transfer valve control wheel to the pressure position, and apply the same steps as performed for operation from hydrant or draft.

Advance the throttle until desired pressure is obtained. (Do not change the transfer valve position when pump discharge pressure exceeds 30 psi as damage to pump system may occur.)

Shut down the pump and perform cab-breakdown procedures in the same manner as for hydrant or draft operation.

Foam System Operation From Water Tank. Foam can be delivered from any of the discharge hoses and may be delivered while pumping water from any source at a maximum rate of 200 gpm (6% foam) and 350 gpm (3% foam). High pressure operation should be avoided during foam operation.

Complete the in-cab procedures the same way as for other pump operations.

Open the foam system valve which controls water flow from the pressure side of the fire pump to the foam eductor and open the foam tank valve. Adjust the foam metering valve to the desired setting. Adjust the engine throttle gradually until desired pressure is attained.

Shut down fire pump as follows:

(1) Throttle engine down to idle.
(2) Close foam tank valve.
(3) Fully open metering valve.
(4) Open foam flush valve.
(5) Discharge water through the nozzles until clear indications show no discharge of any foam.
(6) Return foam metering valve to stored position.
(7) Close foam flush valve.
(8) Close applicable discharge valves.

Perform cab breakdown procedures.

NOTE: Pump and piping shall be thoroughly flushed after foam system operation from water tank to prevent any corrosive action which may be created by the foam solution.

Exercises (842):

1. When possible, how far below the surface of the water should the strainer be placed for drafting with the P-12?

2. At what speed should the engine operate when priming the pump for drafting?

3. How long should the primer be operated without pump discharge before operation of the primer is stopped to check for air leaks?

4. What should be done after drafting from a salt-water source?

5. Which valve is opened for operation from the water tank that is not opened for operation from a draft?

6. From which discharges may foam be pumped?

7. What is the maximum rate of discharge of foam at 6 percent?

8. How is water directed to the foam eductor from the pressure side of the fire pump?

9. Why is the pump and piping flushed after foam operations?

3-3. The A/S32P-8 Pumper

In this section, we will discuss the 500-GPM Brush and Structural Firefighting Truck, USAF Type A/S32P-8, hereafter referred to as the P-8.

So far, there are six configurations of the P-8 (models M46F, M46FW, M46FA, M46FC, M46FCW, and M46FD). To be sure of the proper operation of the model you are working with, you should check the model number of the vehicle and consult TO 36A12-12-12-1, 3, and 4 for information particular to your specific vehicle. You should also make frequent checks of all vehicle TOs for any changes since your last reading of the TO.

The following major components are mounted on a 153-inch wheelbase, 4x4 (four wheels on the ground, with power to all wheels) chassis. A 600-gallon water tank mounted behind the fire-pump compartment; a 55-gallon capacity foam tank mounted forward of the water tank. Two hose reels are located above the 500-gpm fire pump which is equipped with an electric primer and foam system within the fire pump piping.

Models M46FW and M46FCW are configured with winterization components which will not be discussed.

All models EXCEPT M46F and M46FW are equipped with positive action differentials in both front and rear axles.

843. State required facts about the P-8 pumper.

Cab. The cab is hinged at the front end and will tilt forward approximately 45°, providing access to the engine and front chassis components. A double lock is installed at the rear of the cab to prevent accidental tilt. An access plate is provided behind the right-seat back to allow the engine oil and coolant levels to be checked.

Chassis. The chassis is equipped with double acting shock absorbers front and rear (models M46FC, M46FD and M46FCW, front only), aluminized steel muffler and tail pipe, towing and lifting (models M46FC, M46FD and M46FCW towing and tie-down) attachments, spring stops to cushion contact of springs with the frame, 600-gallon capacity water tank and 55-gallon capacity stainless steel (model M46FA, fiberglass) foam tank, storage compartments and brackets for accessories, and a folding rear step to increase the angle of descent.

Engine. The engine is V-8 design, gasoline fueled design, 391 cubic inch displacement, rated at 199 net horsepower at 3,800 rpm. The engine is equipped with an oil bath air cleaner, manual choke, positive crankcase ventilation, full flow oil filter, and mechanical fuel pump. The engine is cooled by a pressurized coolant system, regulated by a thermostat. An auxiliary electric fuel pump is installed for emergency use.

Transmission. The transmission is semi-automatic, hydraulically operated with six forward and one reverse gear. The transmission assembly consists of a torque converter, planetary gear train, and a hydraulic control system. A hydraulic retarder is incorporated within the transmission. The retarder can be manually actuated to assist the service brakes.

Transfer Case. The transfer case is of two-speed design with declutching mechanism to enable the truck to operate with either front and rear axle drive or rear axle drive only. Shifting mechanism is connected to cab controls to change the gear ratio or engage the front axle drive. Models M46F, M46FW, and M46FA only may be shifted into low range for operation in adverse terrain. The two-speed transfer case was used for economical reasons. The truck will meet all specification operational requirements in high range for normal operations, transfer case shifting not necessary. Shift only for adverse terrain.

Power Takeoff. The fire pump is connected by a drive shaft to a power takeoff assembly. An electromagnetic or hydraulic clutch is incorporated to engage the pump drive. The power takeoff can be engaged while the truck is in motion. However, the power takeoff should not be engaged when the engine speed exceeds 500 rpm.

Service Brakes. Vacuum assist, hydraulically operated, internal expanding shoe type service brakes are installed on each of the four wheels. A vacuum-type brake booster utilizes engine intake manifold vacuum and atmospheric pressure to reduce required pedal effort for effective braking.

Parking Brakes. A mechanically operated, friction parking brake is installed on the transfer case and connected by linkage to a lever in the cab. An electrohydraulic brake lock is installed in the service brake system and connected electrically to the mechanical brake linkage to provide additional parking brakes.

Exercises (843):

1. Why is the double lock installed at the rear of the cab of the P-8?

2. What is the water tank capacity of the P-8?

3. What kind of fuel does the P-8 use?

4. Why is the rear step of P-8 of the folding design?

5. What type of transmission does the P-8 have and how many gears?

6. What is the transfer case on the P-8 used for?

7. The maximum rpm at which the power take-off assembly should be engaged is ______ .

8. What type of service brakes are installed on the P-8?

9. The parking brakes of a P-8 are of what type?

844. Tell pertinent facts about the firefighting system of the P-8.

Fire Pump. The pump is a parallel-series type with volute discharges, designed for operation from either draft, hydrant, or the water tank.

An electrically actuated clutch is utilized to engage the power take-off to acquire power from the truck engine. When the clutch is engaged, the impellers within the pump force water through diverging passages, converting a high volume of the water into pressure.

A hydraulically operated clutch (model M46FD), engaged through fluid pressure from a master cylinder and engine supplied vacuum power chamber arrangement, engages the fire pump. When the pump is operating, water is forced through diverging passages, converting high water volume into required water pressure.

A two-position valve in the pump changes the pump action from parallel (volume) to series (pressure) operation. When the transfer valve is in the VOLUME position, each impeller operates as a separate single-stage pump, working in parallel. Each impeller accepts water from the pump intake and discharges into the pump outlet in high volume. When the transfer valve is in the PRESSURE position, the impellers operate in series. Discharge from the first stage is directed into the suction of the second stage, reducing water volume by one-half and doubling pressure.

The pump is designed to operate at up to 200 psi net pump pressure in the volume mode. The volume mode should be utilized at any net pump pressure under 150 psi. When the pump is operating from the truck tank or draft, the pressure mode may be used when volume is less than 250 gpm and desired pressure is in excess of 100 psi. Desired flow and pressure at the lowest engine speed is the usual guide as to which mode is to be used. When the pump is engaged, centrifugal impellers rotate within the pump housing, creating a partial vacuum that draws water into the pump. As the water is drawn into the impellers the centrifugal force imparts velocity to the water and forces the stream into diverging passages, further increasing velocity of the water to the discharge gates. During normal operation from draft or hydrant, pump operation will be in the VOLUME position. When operating in the VOLUME position both impellers draw water, acting as two pumps, moving a larger quantity of water than when operated in the PRESSURE mode. When operating in the PRESSURE mode, water is drawn into the first stage impeller only. Discharge from the first stage is directed into the intake of the second stage impeller, creating increased pressure at a decreased volume. The discharge from the second stage flows to the discharge outlets of the pump.

Fire Pump Primer. The pump is equipped with an electric priming system. The primer control actuates the primer pump and opens a valve in the line from the fire pump to the primer pump.

Pump Relief Valve. A pressure relief valve diverts water from the discharge to the suction side of the pump to prevent excessive pressure.

Foam System. Foam concentrate from the 55 gallon tank is metered into the pumping system and mixed with the water. The foam system is basically the same as for the P-12 and will not be discussed in detail.

Pressure Computer. Models M46FC, M46FCW, and M46FD are equipped with a pressure computer which is located on the bottom left hand corner of the fire pump control panel and which is internally illuminated. This computer is operated in the same way and governed by the same seven factors as the pressure computer on the P-12, so we won't go into it any further.

Exercises (844):

1. How is power acquired from the vehicle engine to operate the pump on P-8 models except model M46FD?

2. What is the maximum net pump pressure to which the P-8's pump is designed to operate in the volume mode?

3. What is the usual guide as to which mode is to be used for pumping?

4. What type of priming system is employed on the P-8?

5. What is the capacity of the P-8's foam tank?

845. Cite important points about operation of the P-8 from a hydrant.

After selecting a hydrant from which to operate and positioning the vehicle at the hydrant, you should place the transmission range selector lever in neutral (N) position and allow the engine to operate at idle speed. CAUTION: Do not operate the engine in excess of recommended engine rpm for desired fire pump pressures, as damage to the fire pump and pump drive clutch may result. Ensure that the parking brake is applied. NOTE: To engage the service-brake lock on models M46FC, M46FD, and M46FCW, depress the service brake pedal and place the manual switch in the ON position. Release the brake pedal and turn the switch to OFF.

Attach one end of a 2½-inch, or 4½-inch, soft suction hose to the hydrant and the other end to the respective pump suction inlet.

Engage the fire pump by pulling the pump clutch control.

Close the discharge valve controls and lock out the relief valve by turning the control valve adjusting wheel fully clockwise.

Open the hydrant and, if being used, the auxiliary suction valve.

Open the desired discharge valve and adjust engine throttle gradually until desired pressure is attained.

NOTE: Models M46FC and M46FCW have a pressure computer. To use the computer, determine lay size and length, and nozzle size. Use computer to find discharge pressure (not applicable to 1" booster hose). Adjust engine throttle to indicate computed pressure on related discharge valve pressure gage.

If the gage indicates a vacuum before the desired pressure is attained, the maximum volume of water from the hydrant is being delivered. To increase the pressure, use smaller nozzle tips.

When the desired pressure is attained, adjust the auxiliary cooling valve to maintain engine temperature.

Adjust the pressure relief valve by turning the adjustment wheel counterclockwise until the pilot light is illuminated. Turn the adjustment wheel clockwise until the pilot light is extinguished. The valve will now operate at the set pressure. CAUTION: Do not reduce pump pressure to below zero when operating from a hydrant as damage to the water mains will result.

If the engine speed increases with no increase in pressure, the pump is operating faster than the volume of water delivered from the hydrant. Reduce the engine speed slowly until the pressure starts to drop.

Exercises (845):

1. What may be the results of operating the engine in excess of recommended rpm for desired pump pressures?

2. How is the fire pump engaged when operating from a hydrant?

3. The pressure computer cannot be used to determine pressure when using what size hose supplied with the P-8?

4. When pumping from a hydrant and the pressure gage indicates a vacuum before the desired pressure is attained, what is indicated?

5. What will happen if you reduce pump pressure to below zero while operating a P-8 from a hydrant?

6. How can you tell when the pump is operating faster than the volume of water delivered from the hydrant?

846. Explain how to operate the P-8 from a draft.

Operating From Draft. Position the truck as near the water supply as possible and apply the parking brake. To engage service-brake lock on models M46FC, M46FD, and M46FCW, depress service brake pedal and place manual switch in the ON position. Release brake pedal and turn switch to OFF.

Place the transmission in neutral position. Then attach a suction hose to pump suction inlet and attach a strainer to the other end of the suction hose and submerge the strainer in the water. If possible, submerge the strainer at least two feet below the surface of the water and keep the strainer off the bottom. Use every precaution to keep sand, leaves, or other foreign material away from the strainer to prevent restriction of water flow.

Place transfer valve in the VOLUME position and close all discharge valves and drain valves.

Pull pump clutch control to engage the fire pump and actuate the priming pump in the following manner. (1) Adjust engine throttle to operate the engine at 1300 to 1500 rpm. (2) Push and hold pump primer control and (3) When the pressure rises, indicating water entering the fire pump, open the discharge valve slowly and lock in position. Water should enter the fire pump in 10 to 30 seconds of primer operation. If the pump does not discharge within this time lapse, do not continue to operate the primer pump; stop and look for air leaks.

Adjust the engine speed until the desired pressure is attained, and open auxiliary cooling valve.

Adjust the pressure relief valve: turn adjustment wheel counterclockwise until the pilot light is illuminated, then turn the adjustment wheel clockwise until the pilot light is extinguished. The valve will then operate at the set pressure.

Water pressure should increase with increased engine speed. If the engine speed increases with no corresponding pressure increase, change to smaller tipped nozzles. If the water pressure still does not increase, check for air leaks or clutch slippage.

Do not change the transfer valve position when pump discharge pressure exceeds 30 psi, as damage to the pump system may occur.

With the pump discharge pressure 30 psi or less, set transfer valve to the position desired. Operate the pump in the range (transfer valve position VOLUME or PRESSURE) which achieves the desired flow and pressure at the lowest engine speed. In general, the VOLUME position should be used at any net pump pressure under 150 psi, especially when pumping from a hydrant. When pumping from the booster tank or draft, the PRESSURE position may be used when the volume does not exceed 250 gpm, and the desired pressure is greater than 100 psi.

If the needle in vacuum gage or pressure gage fluctuates, adjust the steady valve to remove the fluctuation.

If a shutdown is required for changing hoses or other reasons, slow the engine to decrease water pressure to 30 psi and close the discharge valves. Periodically open the valve to release heated water from the pump to prevent overheating.

Exercises (846):

1. When drafting with the P-8, in what position should the transfer valve be before the priming pump is actuated?

2. What is indicated if the pressure rises while the pump primer control is being pushed in?

3. When drafting with the P-8, what should you do after you have set the pressure with the throttle and before you adjust the pressure relief valve?

4. If, while operating from a draft, the engine speed increases with no increase in pump pressure and changing to smaller nozzle tips does not cause the pressure to increase, what should you do?

5. When pumping from a draft, under what conditions may you use the pressure position on the pump?

6. While pumping from a draft, the pressure should be lowered to ______ psi before you close the discharge valves. If this shutdown is prolonged, why should you periodically open the discharge valve?

847. Explain how to operate the P-8 pump from the water tank and how to operate the foam system.

Operating From Water Tank. The pump can be operated while the truck is in motion by operating from the water tank only. To put the pump in operation for water tank operation, place transfer valve in VOLUME position. Start the pump at either pump clutch control on the pump panel, or pump switch on the truck cab instrument panel, and open water-tank suction-line valve.

Ensure that the discharge valves, drain valves, and hose reel valves are fully closed.

Actuate the priming pump in the same manner described for operation from draft.

After the pump is primed, if lower engine speed is desired, change the transfer valve to PRESSURE.

When pumping a small volume of water through a fog nozzle or small hose tip, switch from VOLUME to PRESSURE periodically to remove air. Do not change the transfer valve position when pump discharge pressure exceeds 30 psi as damage to the pump system may occur.

With the pump discharge pressure 30 psi or less, set transfer valve to the desired position.

Foam System Operation. The foam systems may be operated in conjunction with any of the three mentioned pump operations and foam may be discharged through any pump discharge valve.

To discharge foam from the P-8, you should operate the pump as described in the foregoing sections. Once the pump is in operation, open the foam system valve for controlling the flow of water from pump pressure side to the eductor. Adjust the foam metering valve to the appropriate setting, determined by the discharge gpm, hose line layouts, and strength of foam (6% or 3%).

After adjusting the metering valve, open the foam tank valve and the desired discharge valve for 2½-inch line or hose reel valve for booster hose operation. Last open the hose nozzle for discharge.

Exercises (847):

1. When may the P-8 pump be operated with the truck in motion?

2. After the pump is primed, when should the transfer valve be changed to pressure?

3. How do you remove air from the system when pumping a small volume of water through a small hose tip or fog nozzle?

4. To discharge foam from the P-8, the pump must be operated from what water source?

5. What determines the foam metering valve setting for foam operation?

CHAPTER 4

Crash, Fire, and Rescue Vehicle Operations

NEW CRASH, FIRE, and rescue vehicles and equipment are being developed constantly in order to add to the success of the crews during emergency operations. With aircraft becoming more numerous, more complex, and larger, the improvements will never exceed the demand. As a member of a firefighting organization, you will be expected to be alert to the improvements on current vehicles and equipment. You must promote in your organization the creation of new ideas which may be responsible for better equipment than that now used. And you must encourage training in the proper use of all current equipment.

We will not discuss all the various types and models of crash, fire, and rescue vehicles now in use by the Air Force. Our discussion will be limited to the newer and/or more widely used vehicles.

4-1. The A/S32P-10 Forcible Entry Vehicle

In the early 1970's, the Air Force introduced the A/S32P-10, Forcible Entry Fire Fighting Truck, to replace its fleet of aged and well-worn R-2 series rescue vehicles. As with most other equipment in use, it wasn't long before a second model of the P-10 was with us. Although still carrying the same identification as the first series of vehicles, there were changes made in the newer model. In this section we will be discussing the older of the two models. Should you desire to compare the two vehicles more closely, you should obtain copies of the technical orders for both models and make your own comparisons.

The P-10 is an all-weather firefighting and rescue vehicle designed for fast action and high maneuverability, both on and off hard surface roadways, and is equipped with portable quick-operation, readily accessible equipment.

848. State identifying characteristics about the P-10 and its components.

The firefighting truck is a basic four-wheel-drive, four-door, crew cab chassis with utility body, powered by a V-8 gasoline engine. The vehicle is equipped with a four-speed manual transmission, front-mounted winch, top-mounted electronic siren/PA system, twin rotating beacons and adjustable spotlights, and rear-mounted flood light and spotlight. The firefighting, forcible entry, rescue and life saving equipment is safely stowed in various special compartments in the utility body and the crew cab.

The truck and chassis is a Dodge W-200 Model. Mounted on the truck is a utility body manufactured by Pierce Manufacturing, Inc., Appleton, Wisconsin 54911. All of the forcible entry and rescue equipment, except the front-mounted winch, can be operated away from the truck and is in no way dependent on the truck for power or operation.

Crew Cab. The crew cab is a four-door cab with a one-piece stationary windshield and a stationary rear window. Twin electric windshield wipers and manual windshield washers are provided. All doors have conventional roll-down windows and push-button door locks. Oversize adjustable outside rear-view mirrors are mounted on each side of the cab. The driver's seat is adjustable forward and rear and extends the full width of the cab. A single rider's seat is located behind the driver's position. Storage racks are installed behind the driver's seat for storage of the power saw, air breathing apparatus, portable electric lanterns, and hydraulic jack. A thermostatically controlled, water-circulating type personnel heater/defroster is installed underneath the dashboard on the right side.

Utility Body. The utility body is of welded steel construction having two rear doors, left-hand and right-hand top-loading panel doors, two left-hand side doors, two right-hand side doors, and a sliding top panel for easy access to stowed equipment. The doors operate on piano-wire type hinges and have latches which are either lever or push button operated. No keys are needed to operate these latches. Doors have either spring loaded brackets or retainers to hold them in the open position.

Truck Engine and Clutch. Power for the truck is supplied by a 90° V-type, eight-cylinder gasoline engine which develops 199 net horsepower at 4400 rpm. The engine is pressure lubricated and water cooled. The power output of the engine is transferred directly to the transmission through a dry disc clutch. The clutch is mechanically actuated by the clutch pedal through a mechanical linkage.

Transmission. The transmission is a manually operated, four-speed model with the shift lever on the transmission. All gears are of helical design except first and reverse which are spur type. The countershaft and all its gears are a single unit. Engagement of the third and fourth gears is aided by pin-type synchronizers, and the second-speed gear is also synchronized. The output of the transmission is coupled to the transfer case through a drive shaft with universal joints.

Transfer Case. The transfer case is a two-speed unit which transmits power to the front- and rear-drive axles through drive shafts with universal joints. Shifting of the sliding clutch gears in the transfer case is controlled by a single shift lever in the cab. Power for the front winch is also taken off the transfer case at a power takeoff and transmitted to the winch through drive shafts. The power takeoff clutch control is located on the crew cab floor.

Front Axles. The front axles are steerable drive type with the inner and outer axle shafts connected through universal joints which revolve in the steering knuckle. The drive pinion and differential case with drive gear are mounted directly in the carrier section assembly. The front-axle drive shaft outer end connects through a splined slip-joint drive flange to the wheel hub.

Lockomatic Hubs. The front wheels are equipped with lockomatic hubs. The hubs are designed for use on four-wheel drive vehicles. The lock position is needed only for four-wheel operation.

Rear Axles. The rear axles are of an integral design whereby the drive pinion and differential case with drive gear are mounted directly in the carrier section of the axle housing.

Brake System. The truck is equipped with a vacuum-assisted hydraulic service brake system actuated by a foot pedal in the cab. The service brakes are drum type with internal-expanding shoes on all four wheels. The parking brakes are the mechanical internal-expanding type on the rear wheels only.

Fuel System. The fuel system is aconventionaltype with fuel tank, fuel pump, fuel filter, carburetor, air cleaner, fuel lines and vacuum lines. The carburetor is a dual throat downdraft type. The air cleaner, which is installed directly on top of the carburetor, uses a dry-type replaceable paper element. The fuel pump is a diaphragm type located on the lower right side of the engine and driven from the camshaft. The fuel filter is a replaceable throwaway type. The 50-gallon gas tank is located at the rear of the vehicle under the frame. The gas fill cap is located in the center rear of the truck just above the running board.

Electrical System. The truck's electrical system is a 12-volt system powered by a single 70-ampere-hour battery and an engine mounted, belt-driven, 60-ampere alternator. Circuits are fused for short-circuit overload protection. The fuse block is located in the crew cab on the left side of the firewall. The firetruck is radio interference suppressed in accordance with MIL-STD-826 for electromagnetic interference.

Exercises (848):

1. What is the one item of equipment on the P-10 that is dependent upon the truck itself for operation?

2. What items of equipment are stored behind the driver's seat in the racks provided there?

3. How are the compartment doors kept open on the P-10?

4. How is the engine power transferred to the transmission on the P-10?

5. What type of transmission is used on the P-10?

6. What is the function of the transfer case on the P-10?

7. The P-10 is equipped with what type of brake system?

8. What is the fuel tank capacity and where is the fuel tank located on the P-10?

9. What is the voltage for the P-10 electrical system and from what source is this power received?

849. Give locations and identifying characteristics of the P-10.

Let's take a walk around the P-10 and see what all is on the truck and where it is supposed to be located.

We will start our little tour at the driver's position and all references to left or right will be made as you sit in the driver's seat.

Crew Cab. Take a look around within the crew cab and you'll find the following items.

Fireman's axes. The two axes furnished have steel heads with a pick point. Chrome plated blade cover brackets and pick covers are mounted on the front crew cab doors. It is permissible to relocate the fire axes to the tool compartment subject to local fire chief approval. However, all rescue personnel must be advised of this change.

Harness cutters. The two harness cutters mounted below the fireman's axes on each front door have two converging steel blades for ease in cutting seatbelts and harnesses to release accident victims.

Electric hand lanterns. The two hand lanterns furnished are portable, battery powered electric lights utilizing a 7½ volt dry cell battery. The lanterns have two levels of brightness, a normal illumination level and a bright illumination level.

Air breathing apparatus. Two sets of breathing apparatus are supplied, each in a separate protective case. The purpose of the breathing apparatus is to supply approximately 30 minutes of air supply to a user working in a toxic or hazardous atmosphere. Air is supplied in a charged air cylinder which is connected to a face mask through hose and valves. The equipment is worn as apparel and is normally put on in breathable atmosphere.

Power saw. The power saw is a portable circular saw powered with a high-speed gasoline engine for use in forcible entry and rescue work. The saw provides fast and safe heavy duty cutting power without relying on auxiliary equipment. It is capable of cutting through sheet steel, all types of ferrous and nonferrous metal plate, stone, concrete, wood and plastic materials. Three different types of circular blades are provided. The saw employs manual pull-cord type starting.

The complete rescue saw kit contains the K-12 saw, heavy duty steel carrying case, spare parts and a field service kit, one gallon safety gasoline can, a quart of 2-cycle engine oil, a quart of gasoline stabilizer, one 12-inch concrete cutting abrasive blade, one 12-inch steel cutting abrasive blade, one 12-inch carbide tip blade, one pair of safety goggles, one spare drive belt, and a spare air filter.

Utility Body. Most of the rescue and fire equipment is stowed in the various compartments of the utility body.

In the left side compartments as we come to them we will find the following.

Portable lighting equipment. The two quartz-iodide portable floodlights are used to illuminate desolate areas where stationary electrical power and lighting facilities are not available. These floodlights are powered by the portable electric generator and have vertical directional adjustments, as well as focus to insure proper lighting of work area. Two 50-foot extension cords and a "Y" connector are furnished to connect the floodlights to the portable generator. The cords and connector have twist-lock connectors with rubber boots for water tight connections and are fabricated from a heavy duty oil-resistant, waterproof three-wire conductor, size No. 16, rated at 600 volts.

Tube cutter (de-arming tool). The hose and tube cutter is used to disarm ejection seats in aircraft by cutting the initiator hoses in the ejection system.

Pike pole. One pike pole with 6-foot fiberglass handle is furnished for prying, poking, and hooking applications.

Folding litter. The folding litter is collapsible and can be folded into a four foot length.

Shovel. One short handled shovel is furnished.

Portable generator. The engine-driven 1000 watt generator is a portable electrical power supply unit used to furnish power for the portable floodlights. The generator is direct-driven by a one-cylinder 4-cycle engine, and features a permanent magnet rotor which completely eliminates brushes, diodes, slip rings, or commutators. The voltage and frequency of the generator output is regulated automatically by a mechanical governor built into the engine. The engine has vertical crankshaft and a crankcase for motor oil. Oil is not mixed with the fuel but is force fed by a positive displacement pump running in oil. Manual pull-cord type starting is employed. The generator is equipped with two three-pronged electrical receptacles.

Going around to the rear of the truck and opening the center compartment, we will find these items.

Safety pins. The 12 safety pins are used to prevent accidental release of ejection seats in aircraft. These pins are stowed inside the left rear door of the utility body.

Fire extinguishers. Six dry chemical fire extinguishers are furnished. Each is a hand portable and cartridge-operated type that is operative in cold weather. One extinguisher is for metal fires. The rest are individually rated for use on ordinary combustion fires, flammable liquid fires, or electrical fires. (The red extinguisher is for use on class A, B, and C fires. The blue is for class B and C fires and the yellow is for class D fires.)

Engine-driven blowers. The two portable engine-driven blowers are used to cool hot aircraft brakes or to remove smoke and fumes from enclosed areas. Each blower consists of a large fan driven by a one-cylinder, two-cycle, gasoline engine inclosed in a steel shell and frame. The unit operates at a fixed speed. Grilles are provided to prevent injury to personnel. Manual pull-cord starting is employed.

Plugs. Six oil-resistant, hard rubber plugs and six hardwood plugs are conical in shape, having a length of 8 inches and a base of 2 inches. These plugs are used for plugging fuel lines on aircraft, and are stowed inside the right rear door of the utility body.

To continue our trip down the right side of the truck from the rear to the front we will find more equipment.

Insulated cutter. The insulated cutter is capable of cutting ⅛-inch material and has a rated insulation resistance of 20,000 volts.

Pry-axes. The three pry-axes are multipurpose forcible entry tools designed for use at fires, wrecks, lock-outs, and related emergencies. The pry-axe has an axe head with a pike point on one end and a claw at the other and can be used for chopping, prying or cutting. The handle of the pry-axe is insulated for gripping and for protection against freezing on the bare metal in severely cold weather. It was not designed to protect against electric shock. These pry-axes are carried in holsters and are belted on the operator with truckman belts. Truckman belts are also furnished for wrapping, tying, and girdling applications.

Tool kit. The tool kit has a canvas carrying bag which holds the following items:

1. Hammer, hand, ball peen, 1¼ pound.
2. Wrench, pipe, 14 inch.
3. Shears, metal cutting, hand, combination, 8-inch normal size.
4. Pliers, lineman's, 8-inch nominal size.
5. Pliers, slip joint, 10-inch nominal size.
6. Screwdriver, 8-inch nominal size.
7. Screwdriver, 6-inch nominal size.
8. Screwdriver, 4-inch nominal size.
9. Wrench set, knife type, socket head (AW5K).
10. Wrench set, knife type, socket head (two each) (AW9K).
11. Screwdriver, cross tip, straight, size 4 inches (Phillips).
12. Screwdriver, cross tip, straight, size 4 inches (Reed-Prince).
13. Screwdriver, cross tip, straight, size 3 inches (Reed-Prince).
14. Chisel, cold, flat, ¾-inch edge.

Safety goggles. Three standard industrial goggles are included for personnel eye protection.

Rope. Two manila ropes are provided; each being 75 feet in length, ¾-inch diameter, and designated manila T-R-605, type M.

Well, we're back to the crew cab again and already know know what's in there so that just about does it, doesn't it? Nope! We are suppose to be on a walk around the entire vehicle, so let's go on around the front to get back to where we started.

Just walk around the front of the truck and look at what we find.

Winch. The 8000-pound, mechanical drum-type winch is mounted on the front bumper and supporting frame at the front of the truck and is driven from a power take-off on the transfer case through drive shafts. It is equipped with 200 feet of ⅜ inch diameter galvanized aircraft cable terminating in three-pronged grapnel. Winch operation is controlled by the transfer case shift control, power take-off clutch and transmission shift in the crew cab. A second clutch on the winch itself permits disengaging the drum to unreel cable. The winch is protected by a shear pin to prevent overload. The winch incorporates an automatic brake which holds the load when power is released. This adjustable safety brake is an external contracting, self-energizing brake, operating on the worm shaft brake drum; and although it offers little resistance to forward rotation, it instantly checks any tendency to rotate backward under load. This brake is adjustable and may be released for any special purpose.

Exercises (849):

1. Explain what must be done if the fireman's axes are to be relocated to the tool compartment.

2. What are the two levels of brightness of the electric hand lanterns?

3. How much gasoline stabilizer and 2-cycle engine oil should there be in the power saw kit?

4. How long is the pike pole on the P-10?

5. Where is the folding litter normally stowed?

6. How many safety pins should there be on the P-10 and where are they located?

7. If you are told [illegible] get an extinguisher from the P-10 for use on a magnesium fire, what color extinguisher would you get?

8. There are a total of ______ plugs stowed inside the right rear door of the utility body. Of these, ______ are oil-resistant ______ ______ plug and ______ are ______ plugs.

9. Besides being used to carry the pry-axes, the truckman belts may also be used for what applications?

10. A total of how many screwdrivers are in the tool kit?

11. How much rope of what size is supplied with the P-10?

12. What is the capacity of the winch on the P-10?

13. Describe the cable used on the P-10 winch.

14. How is the winch provided overload protection?

850. Explain how to operate given vehicle components.

The truck operates in the same manner as any other automotive vehicle powered by an internal combustion engine. Operators should become familiar with all truck controls and gages prior to starting and operating the vehicle.

Power Takeoff Lever. The power takeoff lever provides driving power to the winch. The truck must be stopped with transmission and transfer case in neutral before engaging the power take-off lever.

Clutch Pedal. Clutch pedal is used to disengage the clutch. Selection of transmission gears, transfer case power modes, or takeoff engagement are accomplished with the clutch disengaged.

Selection of Driving Range. The transmission must always be in neutral position when the transfer case shift lever is used to select a driving range. The rear axles are engaged during any drive position of the transfer case. The front axles are engaged during just two positions, four wheel low range and four wheel high range. When the shift lever is in neutral, the truck will not move because the transfer case is disengaged from the propeller shafts to the front and rear axles. The neutral position is used only for operation of the winch. Selection of driving ranges is subject to the following:

1. Use four-wheel-drive, low-range (4L) for hard pulling on steep grades or in loose sand or mud. Do not use (4L) range under normal road conditions or with lockomatic hubs disengaged.
2. Use rear-wheel-drive, high-range (2H) on all flat surface highways under normal conditions. The use of four-wheel-drive during normal driving conditions causes unnecessary strain and wear. Lockomatic hubs must be in free position in (2H) driving range to prevent excessive wear on front end components.
3. Use four-wheel-drive, high-range (4H) for maneuvering on side hills, slippery roads, ice, or rough terrain where speed is necessary. Lockomatic hubs must be in lock position to provide the four-wheel gear compression braking needed under these conditions. Do not shift into four-wheel-drive (4L or 4H) above the speed of 20 miles per hour.
4. The clutch must be disengaged to permit shifting the transmission. Because the gears may tend to drift with the engine running and both the transmission and the transfer case in neutral, the transfer case should be shifted immediately after putting the transmission in neutral to avoid gear clash. Gear clash can also be avoided by releasing the clutch pedal slightly to mesh gears before shifting.

Lockomatic Hubs. The hubs are hand operated using just the fingers and are set in the desired position at the front wheels with the truck stopped and brakes set. Turn each hub fully clockwise to lock and counterclockwise to free. Arrows on the hubs indicate the condition. The transfer case shift lever should be placed in 4L or 4H position to lock the hubs and in 2H to free the hubs. The Lockomatic hubs should always be engaged or disengaged with the vehicle on level surface.

Operating Winch. To put the winch into operation, you should start the vehicle and proceed as follows:

1. Insure that the parking brake is set.
2. Put the transmission and transfer case in neutral.
3. Disengage the winch clutch on winch by moving the lever up.
4. Pull out the cable as required and hook grapnel to object as necessary.
5. Engage the winch clutch on the winch by moving the lever down.
6. Pull out (up) on the take-off knob on the floor inside the cab.
7. Put the transmission in a forward gear and release the clutch to wind.
8. Put the transmission in reverse gear and release the clutch to unwind.
9. Accelerate the engine as required.

NOTE: A winch shear pin is located on the front universal joint of the winch drive shaft. If the winch is loaded in excess of safe operation, the shear pin will break before damage occurs. To replace the shear pin, knock out the broken pieces of the pin. Then, align the pin holes and install a new pin. The shear pin is held in place with a cotter pin.

Exercises (850):

1. What must you ensure before engaging the power take-off lever?

2. The clutch must be disengaged before what actions are accomplished?

3. The transfer case must be in what position(s) during front axle engagement?

4. When should 4L (four wheel drive low range) NOT be used?

5. Why must the lockomatic hubs be in free position while in (2H) driving range?

6. What is the maximum speed at which you can shift into four-wheel drive?

7. What is used to operate the lockomatic hubs?

8. How can you tell which condition the lockomatic hubs are in?

9. In which gear should the transmission be placed to unwind the cable from the winch?

10. Explain how to replace a broken shear pin in the winch of the P-10.

4-2. The Airfield Ramp Fire Fighting Trucks

When the first airfield ramp firefighting vehicle, the A/S32P-6, was introduced, it was to standardize the ramp vehicle Air Force wide to get away from the many "homemade" vehicles then in use. As the years passed, the P-6 started showing signs of wear and a replacement was called for.

In keeping with the practices of modernization of both equipment and firefighting agents, the A/S32P-13 was developed and put into service. Soon after its service life began, it was determined that further improvements were needed, henceforth, the P-13A. The design improvements will not stop with these vehicles but will continue as long as necessary until the much sought after "perfect vehicle" is found.

851. State important characteristics of the P-13 and P-13A vehicles.

The A/S32P-13 and P-13A Airfield Ramp Fire Fighting Trucks are designed for use in combating fires that may occur at flight line and other base facilities. The firetruck is basically a pickup truck with two firefighting units (dry chemical and halon) mounted in the bed of the truck. A spotlight, warning beacon, and siren (speaker and amplifier) are attached to the roof of the truck cab. This truck is a completely self-contained and mobile firefighting vehicle. The two firefighting units operate independently of each other with their own chemical and expellant supplies mounted on the vehicle. Each extinguishing unit features two-step activation.

Dry Chemical Unit. The dry chemical fire extinguishing unit uses Purple "K" (PKP) as the primary extinguishing agent and nitrogen as the expelling agent. This unit is designed for use on class B and C fires, and is very effective for exterior running and flowing class B fuel fires. This agent has a limited capability (flame knockdown) on class A fires. The components of the dry chemical unit are a 350-pound capacity chemical tank, a 250-cubic-foot capacity expellant (nitrogen) cylinder, pressure regulator, control valves and piping, two pressure gages, 100-foot expellent hose on a reel and a dry chemical expellant nozzle.

Halon Unit. The Halon fire extinguishing unit uses Halon 1211 (LIQUIFIED GAS) as the extinguishing agent, and nitrogen as the expelling agent. This unit is designed for class B and C fires, and is very effective for interior compartments and aircraft engine fires. It is considered a clean agent for this application. This agent has a limited capability (flame knockdown) on class A fires. Components of the halon unit are: a 507 pound capacity chemical tank, 110 cubic foot capacity expellant (nitrogen) cylinder, pressure regulator, control valves and piping, two pressure gages, 100 foot expellant hose and a halon expellant nozzle.

Specifications. The following is a list of specifications covering items we will be discussing on the P-13 and P-13A.

Vehicle

Model	A/S32P-13 and A/S32P-13A
Type	Truck, Fire Fighting, Airfield Ramp

Truck	A/S32P-13	A/S32P-13A
Length, in.201.7	201.7	205.64
Width, in.	82.0	86.0
Height, in. (max.)	83.0	82.0
Wheel Base, In.	131.75	131.00
GVW, lb. (actual)	7285	7245
Manufacturer	IH	AMG
Model	1210	46
Type Pickup	Bonus Load	Series T20

Dry Chemical Fire Fighting Unit

Manufacturer	The Ansul Company
Model	S-350
Type of Agent	(Specification O-D-1407) PKP (Purple "K")
Expellant	Nitrogen
Capacity (Nitrogen Cylinder)	250 cu. ft.
Pressure (Charged Cylinder)	2265 psi
Capacity (PKP Tank)	350 lb
Operating Pressure	225 ± 25 psi

Halon Fire Fighting Unit

Refurbished By	The Ansul Company
Model	1211
Type Agent	Bromochlorodifluoromethane
Expellant	Nitrogen
Capacity (Nitrogen Cylinder)	110 cu. ft.
Pressure (Charged Cylinder)	2100 psi
Capacity (Halon Tank)	507 lb.
Operating Pressure	200 – 225 psi

Hose Reels

Manufacturer	Tokheim Corp.
Model	MFT 22-10-15A
Hose Diameter (Inside)	1 in.
Hose Length	100 ft.

Halon Nozzle

Manufacturer	The Ansul Company
Hose Connector	1 in. 11½ NPSH Swivel Union
Rate	305 PPM ± 5%
Effective Range	35 ft.

Dry Chemical Nozzle

Manufacturer	The Ansul Company
Hose Connection	1¼ in. 11½ NPSH Swivel Union
Rate	7.25 PPS ± 10%
Effective Range	53 ft.

Exercises (851):

1. How many firefighting systems are on the P-13s and what type of agent is used?

2. How many steps are required for activation of each unit?

3. What is the primary agent used in the dry chemical unit?

4. What class of fire(s) is the dry chemical unit designed to be used on and what types of fire(s) is it effective against?

5. What is the capacity of the dry chemical agent tank?

6. What type of agent is Halon 1211?

7. On what type of fire(s) is Halon 1211 considered very effective and why?

8. How long is the expellant hose on the Halon 1211 system?

9. What is the operating pressure of the dry chemical unit?

10. The dry nitrogen unit uses ______ as an expellant and the storage cylinder has a fully charged pressure of ______ psi.

11. The expellant hoses on both units have an inside diameter of what size?

12. What are the effective ranges of the extinguisher nozzles?

852. Explain how to operate and secure after operation the dry chemical fire extinguishing unit on the P-13/P-13A.

Operation. The dry chemical fire extinguishing unit can be activated from either side of the vehicle without having to enter the bed of the truck. The hose can be unwound from the reel without lowering the tailgate.

The steps for operation of the unit are as follows:

Step 1. From either side of the truck, lift up the dry chemical and nitrogen actuation shafts to the stop position.

Step 2. Unlock hose reel by loosening reel locking wheel located on the right side of the left hose reel.

Step 3. Release nozzle tie down (P-13A only) and pull the dry chemical nozzle free of its bracket on the left side of the truck bed. Unwind all the hose from the reel for maximum efficiency.

Step 4. Be prepared for strong nozzle reaction. Pull the trigger on the nozzle (P-13) or push nozzle control forward (P-13A) and direct stream at the base of the fire with a slow side-to-side sweep of the fire area. Continue sweeps until the fire is extinguished.

Securing After Operation. The shut down procedures are as follows:

Step 1. Close tank valve located on the left side of the tank in the piping for the agent tank.

Step 2. Close dry chemical valve from either side by returning actuation shaft to the horizontal position.

Step 3. Open hose clean-out valve located in the piping on the left side of the agent tank.

Step 4. Open dry chemical nozzle until stream is clear of dry chemical, then close.

Step 5. Close nitrogen cylinder valve using the following procedure:

a. Return nitrogen actuation shaft to the horizontal position from either side of the truck.

b. Turn handwheel, located on top of the nitrogen tank, counterclockwise to full open position.

c. Push quick-opening operating lever, located on the nitrogen tank valve, down while rotating the nitrogen valve shaft clockwise to its stop (flat on shaft vertical).

d. Close nitrogen valve hand tight by turning the handwheel clockwise.

Step 6. Open dry chemical nozzle to relieve all pressure from piping and hose line.

Step 7. Slowly open vent valve on top of chemical tank to relieve all pressure in the tank.

Step 8. Remove handcrank from the side of the hose reel, insert crank into the cranking slot on the front of the hose reel, and wind hose on reel. Return nozzle to its bracket, secure with tie down (P-13A only), and tighten reel locking wheel.

Step 9. Return control valves to the ready position. The tank valve should be open; the hose clean-out valve, vent valve, dry chemical valve, and nitrogen cylinder valve should all be in the closed position.

Exercises (852):

1. The dry chemical unit on the P-13 must be activated from which side of the bed?

2. What is the first step in activation of the dry chemical unit?

3. To unlock the dry chemical hose reel, you must do what?

4. How many feet of hose should be unwound from the dry chemical hose reel for maximum efficiency of the unit?

5. How is the dry chemical nozzle on the P-13A activated?

6. When securing the system after operation, how is the dry chemical valve closed?

7. To clean out the piping and hose, the nozzle should be opened for how long after the dry chemical valve is closed and clean-out valve is opened?

8. In what position must all of the valves in the dry chemical unit be to be in the ready position?

853. Explain how to operate and secure after use the Halon 1211 fire extinguishing unit on the P-13/P-13A.

Operation. The Halon 1211 fire extinguishing unit may be activated from either side of the vehicle without having to enter the bed of the truck. The hose can be unwound from the reel without lowering the tailgate.

To put the Halon unit into operation, you should perform the following steps.

Step 1. Pull either of the charge valve handles forward to the full open position. The two charge valves in this unit are connected by a torque tube. One charge valve pressurizes the halon tank with nitrogen and the other opens the line between the halon tank and the nozzle.

Step 2. Unlock the hose reel by loosening the reel locking wheel located on the right side of the right-hand hose reel.

Step 3. Release the nozzle tie down (P-13A only) and pull the halon nozzle free from its bracket. For maximum efficiency you should pull all the hose off the reel.

Step 4. Push the nozzle control forward and direct stream toward the base of the fire. Work the nozzle slowly from side to side until the fire is extinguished. Caution: Clear halon piping and hose line *immediately after use.*

Securing After Use. Once the fire is out and you are ready to "wrap it up and head for the barn", you should secure the unit in the following manner:

Step 1. Pull either of the charge valve handles back to the closed position.

Step 2. Open purge valve located in the piping near the charging valve.

Step 3. Open nozzle until stream is clear of halon, then close the nozzle.

Step 4. Close the nitrogen cylinder valve hand tight by turning the handwheel clockwise.

Step 5. Open the nozzle to relieve all remaining pressure from the piping and hose line. Close the purge valve and then the nozzle.

Step 6. Open the vent valve for only 10 seconds to relieve nitrogen pressure from the halon tank. If venting is continued for more than 10 seconds, unnecessary discharge of halon will result.

Step 7. Open the nitrogen cylinder valve. If nitrogen cylinder requires filling, this valve should remain closed until filling operation is completed.

Step 8. Remove hand crank from the side of the reel, insert crank into cranking slot, and wind hose on the reel. Return the nozzle to its bracket, secure with tie down if so equipped, and tighten reel locking wheel.

Exercises (853):

1. How is halon unit actuated on the P-13A?

2. Should the charge valve torque tube be broken or disconnected, how many valves would you open to actuate the system and what do these valves do?

3. What must be done with the halon unit immediately after its use?

4. How is the piping and hose line of the halon unit cleared of halon?

5. What will happen if you continue venting the halon system for more than 10 seconds at any one time?

6. How is the halon nozzle secured on the P-13A?

854. Explain how to recharge the halon and dry chemical agent tanks and nitrogen cylinders on the P-13/P-13A.

Recharging Nitrogen Cylinders. Each fire extinguishing unit is equipped with a nitrogen cylinder charging valve. This valve allows quick recharging of the cylinders without removing the cylinders from the vehicle. The nitrogen cylinders can also be charged off the vehicle or be removed and replaced with a charged cylinder. Cylinders shall be charged only by qualified personnel trained in this procedure.

Halon unit (mounted). When recharging a halon nitrogen cylinder on the truck, you should accomplish the following steps in the order given.

Step 1. Remove the dust cover from the nitrogen charging valve.

Step 2. Connect a high pressure nitrogen charging source to the charging valve.

Step 3. Check to assure that the nitrogen cylinder valve is open.

Step 4. Charge the cylinder to its rated capacity of 2100 psi at 70° F.

Step 5. Remove the nitrogen source from the charging valve and replace the dust cover.

Dry chemical unit (mounted). To recharge a dry chemical nitrogen cylinder on the truck, proceed according to the following steps.

Step 1. Close the tank valve on the dry chemical tank.

Step 2. Open the vent valve on the dry chemical tank to release the nitrogen pressure.

Step 3. Assure that the hose clean-out valve is closed.

Step 4. Remove the dust cover from the nitrogen charging valve.

Step 5. Connect a high pressure nitrogen charging source to the nitrogen charging valve.

Step 6. Turn the nitrogen cylinder valve handwheel counterclockwise to the full open position.

Step 7. Charge the cylinder to its rated capacity of 2265 psi at 70° F.

Step 8. Assure that the nitrogen valve shaft is in the vertical (closed) position. Close the cylinder valve hand-tight by turning the handwheel clockwise.

Step 9. Remove the charging source from the charging valve and replace the dust cover.

Step 10. Open the tank valve and then close the vent valve on the dry chemical unit.

Halon unit (dismounted). Charging the halon nitrogen cylinder off the truck is accomplished in the following manner.

Close the nitrogen cylinder valve and disconnect the flexible tube from the pressure regulator. Disconnect the pressure regulator from the valve. Loosen the clamps securing the cylinder and remove the cylinder from the truck.

Install a suitable adapter in the nitrogen cylinder valve port and connect it to a source of high pressure nitrogen. Open the nitrogen cylinder valve and charge to 2100 psi at 70° F. Close the nitrogen cylinder valve, disconnect the source, and remove the adapter from the valve.

Reinstall the cylinder in the truck, connect the pressure regulator and flexible tube, and open the nitrogen cylinder valve.

Dry chemical unit (dismounted). Charging the dry chemical nitrogen cylinder off the truck is accomplished by following these steps.

1. Disengage the linkage from the nitrogen cylinder valve by removing the retaining ring, bolt, and nut. Secure the quick-opening operating lever to the valve body using pressure-sensitive tape or wire so the lever cannot be moved while the cylinder is disconnected from the system.
2. Disconnect the hose from valve and temporarily plug the port in the valve.
3. Loosen clamps and remove the cylinder from the truck.
4. Remove the temporary plug, install a suitable adapter in the nitrogen cylinder valve port and connect it to a source of high pressure nitrogen.
5. Open the nitrogen cylinder valve and charge

to 2265 psi at 70° F.

6. Assure the nitrogen valve shaft is in the vertical (closed) position. Close the nitrogen cylinder valve handwheel, disconnect source, remove adapter from the valve, and temporarily plug the port in the valve.

7. Reinstall the cylinder in the truck, remove the temporary plug, and connect hose and linkage.

8. Remove tape or wire from quick-opening operating lever.

Nitrogen Cylinder Replacement. Replace the low pressure cylinder with a previously charge/cylinder by following removal and installation procedures in the paragraphs above. If necessary adjust the pull cable to account for any cylinder height variation.

Recharging Halon Tank. Connect the fill hose to a supply tank and open the vent valve until it is just cracked. Remove the dust cap from the fill hose and the plug from the charging coupling. Connect the fill hose to the agent tank charging coupling.

Pressurize the supply tank to 100 psi with dry nitrogen or dry air. Open the supply tank transfer valve and pressure fill agent tank until the level gage indicates Fs (full safe/green). *Do not overfill tank.* Close the supply tank transfer valve and immediately close the vent valve. Disconnect the fill hose from the agent tank charging coupling. Install the dust cap on the fill hose and the plug in the charging coupling.

Recharging Dry Chemical Tank. Open the vent valve to insure the chemical tank is depressurized. Remove the fill cap and close the vent valve. Place the funnel in the fill opening and fill to the top of the tank with dry chemical without compacting the agent. Clean the fill opening threads, gasket, and seating surface. Replace the fill cap and secure hand tight.

Exercises (854):

1. Provision is made for charging the nitrogen cylinders on the P-13 while they are in what position(s)?

2. When recharging the halon unit nitrogen cylinder, it must be filled to its rated capacity of _______ psi at _______ ° F.

3. Before charging the dry chemical unit nitrogen cylinder to its rated capacity of _______ psi at 70° F, you must insure that which valves are closed?

4. When the halon tank is being recharged, the supply tank is pressurized to what pressure from what source?

5. The halon tank should be filled until the tank gage indicates what level?

6. When recharging the dry chemical tank, what is the first thing you must do?

7. How much dry chemical should you add to the dry chemical tank when recharging?

4-3. The A/S32P-2 Crash, Fire, and Rescue Truck

The Type A/S32P-2 fire and rescue truck (this designation is commonly shortened to P-2), is one of the largest types of aircraft firefighting trucks being used by the Air Force. The P-2 is designed to combat fires resulting from aircraft emergencies and to assist in emergency rescue operations. This vehicle is designed for quick acceleration (0 to 55 mph in less than 50 seconds) and high horsepower (680 hp) so that rapid arrival at the scene of an emergency is possible, whether travel is over paved roads or rough terrain. The foam extinguishing system is designed to permit attack of the fire to begin while the truck is still moving into position. Installed equipment on the truck includes the basic tools necessary to begin the rescue of the aircraft crewmembers before the arrival of the rescue truck.

855. Give basic characteristics of the P-2.

The P-2. The type P-2 is a high-speed, self-contained, large capacity, foam, aircraft firefighting truck. It has 8x8 drive, cab-forward design, and is propelled by two 340-hp, rear mounted, 6-cylinder, inline engines. When the P-2 arrives at the scene of an emergency, one of the engines is disengaged from the truck drive and is used to power the foam firefighting system.

The firefighting system on the P-2 consists of a foam/water extinguishing system primarily designed to combat aircraft and other large class B fires. It may be used as well to supplement structural firefighting equipment. There are two turrets (one mounted on top of the truck and one mounted just above the bumper), and one handline. The truck cab is designed to seat a crew of four: driver, turret operator, lineman, and crew chief. When a winterization kit, including a booster heater, is installed in this truck, it is capable of operation at temperatures as low as -65° F.

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Specifications. The specifications for the type A/S32P-2 truck are as follows:

General

Type of vehicle	Crash, fire, and rescue truck—high-pressure foam, type A/S32P-2
Gross weight (4 crew members and all tanks full)	66,800 lb (approx 33.5 tons)
Overall length (max)	420 in.
Overall height (with turret)	139 in.
Overall width	118½ in.
Ground clearance	12 in.
Radius of turn	110 ft.
Wheelbase	205 in.
Top speed	65 mph
Fuel capacity	100 gal.
Type of fuel	Gasoline (83 Octane)

Engines

Number	2
Make	Continental
Number of cylinders (each)	6
Maximum brake horsepower (each)	340 hp @ 2800 rpm
Governed Engine Speed	
For pumping	2500 rpm
For road drive	2500 rpm
Oil Capacity with filters (each engine)	24 qt

Heating and Cooling System

Coolant capacity	50 gal
Without booster heater	38 gal
Circulating pumps	
Number	4
Types	3 elec & 1 manual
Booster heater	
Operating fuel pressure	32 psi
Fuel consumption	1 gal-per-hour
Heat output	90,000 Btu

Batteries

Number	2
Voltage (each)	12v
Connection	Series

Auxiliary Generator System

Generator Make	Fairbanks Morse
Speed	2600 rpm
Voltage output	28 vdc
Power	2 kw
Engine	
Make	Wisconsin Motor Co
Horsepower	5.4 hp @ 3600 rpm

Firefighting System

Water tank capacity	2300 gal
Foam tank capacity	200 gal
Water pump	
Make	Waterous
Type	Centrifugal
Capacity	1400 gpm @ 250 psi
Foam pump	
Make	Waterous
Type	Centrifugal
Capacity	60 gpm @ 500 psi
Priming Pump	
Make	Waterous
Type	Rotary gear
Drive	Electric motor
Roof turret	
Make	Bliss-Portland
Number	1
Capacity	1000 gpm
Bumper turret	
Make	Bliss-Portland
Number	1
Capacity	300 gpm
Handline	
Number	1
Length	150 ft (3 sections, 50 ft. ea.)
Make (nozzle)	Bliss-Portland
Capacity (nozzle)	100 gpm @ 100 psi

Exercises (855):

1. What is the total horsepower of the 6-cylinder engines on the P-2?

2. To turn the P-2 in a full circle, you must have a minimum of how much room?

3. If the fuel tank on the P-2 is half empty, how much fuel will it take to fill the tank to its capacity?

4. When changing the oil in continental engines, including the filters, you will need how much oil to fill the crankcase to capacity?

5. How long will the booster heater take to use 8 gallons of fuel if it, the heater, is started and let run without stopping?

6. What type of fire pump is used on the P-2?

7. With the roof turret discharging at its rated capacity, how long would it take to empty a full tank of water on the P-2?

856. Locate components of the water system on the P-2, and tell their use or state their important characteristic.

As a fire protection specialist, you should become thoroughly acquainted with the operation of the roof turret, bumper turret, and handline on the P-2 firetruck. The system has been designed to provide a

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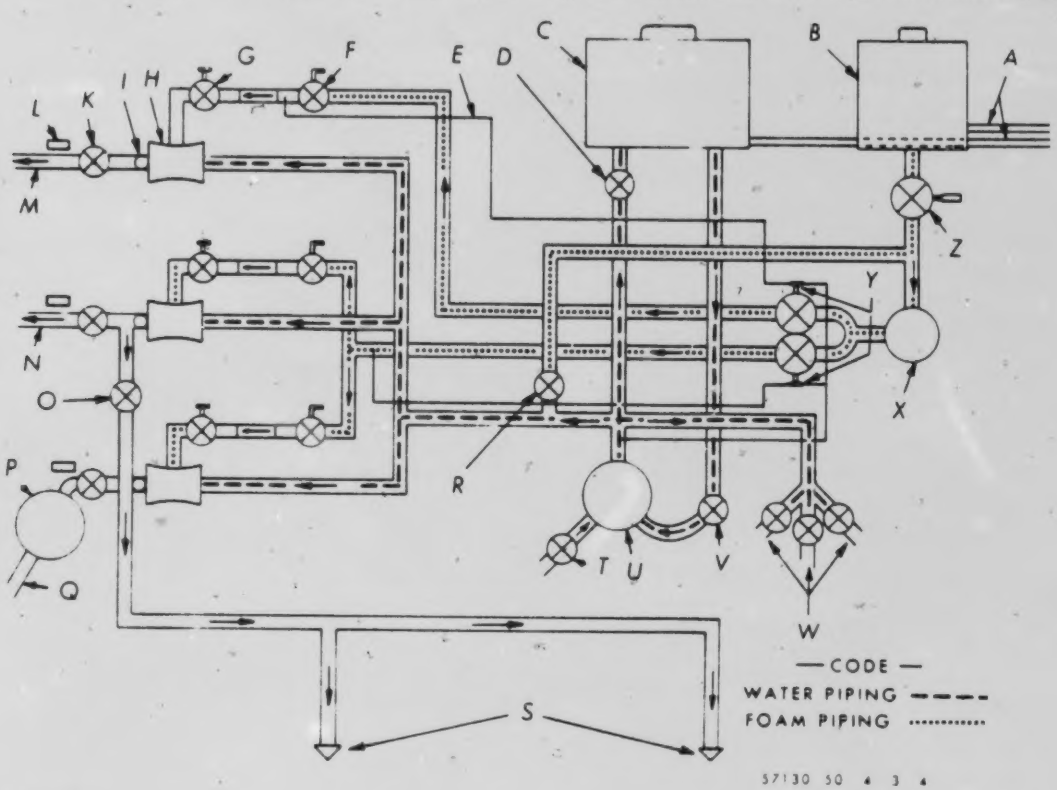
wide selection of discharge patterns and maximum area coverage, permitting use of the equipment in a variety of emergencies. Pump pressures are sufficient to permit simultaneous operation of all dispensing equipment at full capacity. All necessary discharge and drain valves and operating controls are provided for independent operation of the dispensing equipment. A washout system, consisting of a valve and appropriate piping, is provided to clean out the system after a foam operation. An air blowout system is also provided to remove any residual water from the handline piping after the washdown operation.

There are two separate piping systems: one for water and one for foam. The agents come together and mix at the inductors. To help you understand how this firefighting system operates, we will divide it into two parts—the water system and the foam system. First, however, we must point out that there are a number of drain valves in both systems. Since these valves serve the same purpose as their counterparts in other dispensing systems, they will not be discussed here.

Water System Units. The units in the water system include the water tank, water pump, pressure relief valve, inductors, strainers, nozzles, and valves. As we discuss each of the units, refer to figure 4-1. Note that the water system piping is indicated by dashed lines (—) and that arrows (→) are used to indicate the direction of flow in the system. We will discuss the foam system later to show you how the complete system works. First, however, let us consider in detail



A. Filler lines
B. Foam Tank
C. Water tank
D. Pressure relief valve
E. Sensing line
F. Foam discharge valve
G. Foam metering valve
H. Inductor
I. Strainer
K. Discharge valve
L. Microswitch
M. Roof turret
N. Bumper turret
O. Undertruck nozzle discharge valve
P. Hose reel
Q. Handline
R. Washout valve
S. Undertruck nozzles
T. Suction valve
U. Fire pump
V. Water tank shutoff valve
W. Discharge outlets
X. Foam pump
Y. Pressure regulators
Z. Foam suction valve

Figure 4-1. Water and foam dispensing systems.

the various units of the water system, beginning at the tank.

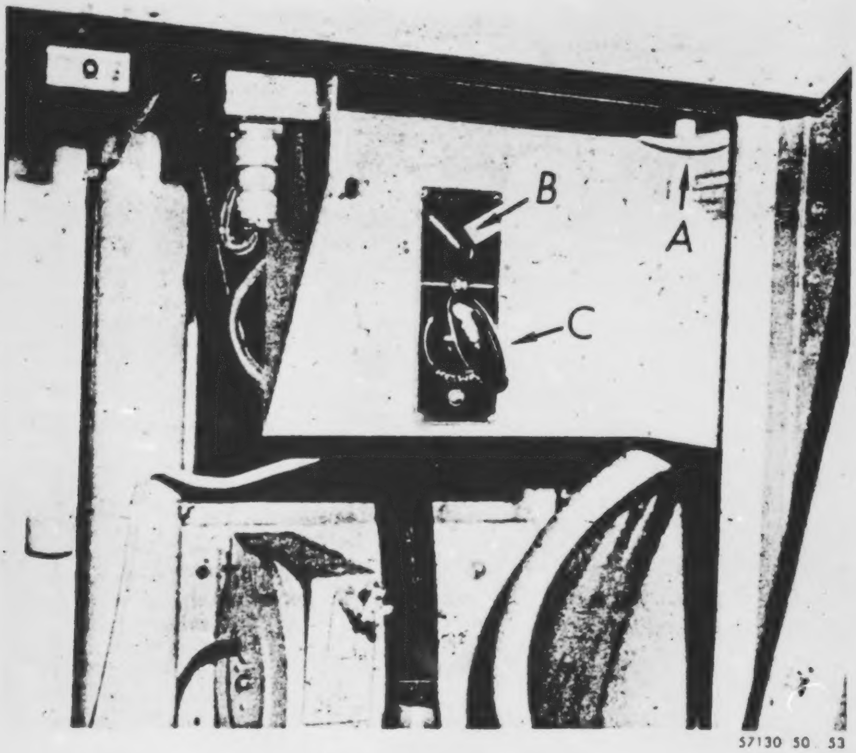
Water tank. The water tank (C) is of welded aluminum construction and is located in the midsection of the truck. The tank is usually filled from a hydrant, through openings (hatches) in the roof of the truck, or through a filler line (A), extending from the rear of the truck to the tank. A check valve in the line prevents reverse flow. You should open the tank cover and remove the tank cap when pressure filling to assure positive escape of the air. A float valve is incorporated in the tank to shut off the flow of water when the proper water level is reached. There is a direct-reading water level gage in the truck cab. To obtain a true reading, you should pump the air out of the lines between the gage and the tank. A small hand-operated plunger mounted under the gage is used for this purpose.

A manual water shutoff valve (V) is situated in the water piping between the tank and the fire pump. This valve should remain open but may be closed to prevent loss of water when certain maintenance jobs are performed. A control handle for the valve is provided in the pump compartment.

Water pump. The single-stage fire pump is driven by a propeller shaft from a gearbox which receives power through the pump engine transmission. The pump body contains the passages for conducting water to the suction eye on each side of a double-suction bronze impeller mounted on a stainless steel shaft. The double-suction impeller has vanes on both sides, giving the effect of two ordinary impellers placed back to back. Stuffing boxes, designed for easy adjustment and packing replacement, control leakage at either end of the impeller shaft. If you have an older model P-2, it should have a primer installed. The priming arrangement is similar to that of a structural fire truck dispensing system in that the priming is done with a gear-type pump driven by an electric motor. The control is a combination manual and electric valve.

Pressure relief valve. Pressure in the system is regulated by a relief valve (D) in the discharge pipe from the pump. The valve prevents bursting of hoses by excessive pressure buildup in the water pump discharge lines. In addition, the valve provides circulation for cooling the fire pump when it is on standby operation, provided the pump is operated at high enough pressure. The pump discharge pressure is indicated on a pressure gage in the cab.

You can check the adjustment of the relief valve by turning the relief valve handle (fig. 4-2, item B)



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A. Emergency foam valve
B. Relief valve
C. Pilot valve

Figure 4-2. Pump compartment valves.

to the OFF position with the pump in operation. Then, at least one discharge valve should be opened and the engine should be accelerated until the discharge pressure gage indicates the desired pressure. Without changing engine speed, you should turn the relief valve to the ON position and observe the pressure gage. If the reading is below the desired pressure, you should turn the pilot valve handle (fig. 4-2, item C) clockwise until the desired pressure is reached. However, if the reading does not drop, the handle should be turned slowly counterclockwise until the gage pressure drops 5 to 10 psi. Then you should gradually turn the handle clockwise until the gage is steady at the desired pressure. When discharge pressures in excess of maximum pilot valve settings are required, the relief valve handle is turned to the OFF position. This will bypass the pilot valve and prevent the relief valve from unseating.

Follow the dashed lines and the arrows shown in figure 4-1, and note that the water from the pump passes through piping to three sets of inductors, strainers, and discharge valves; the upper set is labeled H, I, and K, respectively. This upper set services the roof turret (M), the middle set services the bumper turret (N), and the lower set services the handline (Q).

Inductors. The inductors operate in a manner similar to that of the eductors on the structural firetrucks in that they mix foam with water as it passes through the inductors. Water flowing through the inductor, which is shaped like a venturi, causes an area of lowered pressure to form at the narrowest point. The foam is then drawn in at this point, provided the foam discharge valve is open and the foam pump is operating. The inductors are mounted in the wet piping at the rear of the cab in this particular system. By "wet piping," we mean all discharge piping except the handline piping.

Strainers and nozzles. As indicated in the system diagram, there is a strainer in each line leading to the discharge nozzles. The purpose of the strainers is to strain the water or water-foam mixture coming from the inductors to prevent clogging of the nozzles. A drain valve is provided for draining each strainer assembly after discharging. Each of the discharge nozzles has a manually operated discharge valve of the ball type. The one for the roof turret is labeled K, in figure 4-1. The other discharge valves are arranged on the diagram in each discharge line after the strainer. When you open a discharge valve, water or water-foam mixture is discharged from the nozzle. The microswitches, shown as L in the diagram, work in conjunction with the discharge valves to open the foam discharge valves, f.

The roof turret (M), mounted atop the truck cab, is normally operated hydraulically. However, manual operation from within the cab is possible on later models, and it can also be operated mechanically from the truck roof on earlier models, although this is somewhat awkward as well as dangerous. Hydraulic pressure to operate the turret is supplied by a hydraulic pump mounted on the pump engine, which receives fluid from the turret hydraulic system reservoir located on the firewall of the pump engine compartment. Limits of vertical movements are 70° elevation and 20° depression from the horizontal position. Limits of horizontal movement are 105° on each side of the straight-ahead position. Operating controls are located inside the truck cab on an overhead control panel. The turret discharge valve can be operated electrically by a switch or manually by moving a lever.

As its name implies, the bumper turret (N) is mounted in front of the cab. The operation is basically the same as the roof turret operation except that the remote-controlled bumper turret is manually operated at all times. Limits of movement in the horizontal plane are 90° on each side of center and 30° elevation and 15° depression from horizontal. The depression angle and the design of the bumper turret provide effective coverage at a distance of 20 feet in front of the truck when the turret is used for ground sweep, such as driving through flames during an emergency.

The handline (Q) is similar to those used on other firetrucks. It consists of three 50-foot lengths of 1¼-inch hose and a combination nozzle with a capacity of 100 gpm at 100 psi. It is mounted on a hose reel (P) in a compartment at the front of the truck for rapid use and convenient storing.

Flush and suction valves. There are several other items in the system that have not yet been mentioned, including the flush, or washout valve (R), the suction valve (T), and the hydrant, or outside discharge gates (W). The flush valve is used to wash out the system after foam has been discharged. In this system, flushing is done by setting the various nozzles for foam operation and then opening their discharge valves. Be sure that the foam tank suction valve (Z) is closed during the operation to prevent water from entering the foam tank. It is necessary, of course, to engage the fire pump as well as to accelerate the pump engine to obtain a discharge pressure of approximately 100 psi. Allow the pump to operate until the system is completely clear of foam. The position of the washout valve (R) in the piping system will help you to understand how the washout is done. Note that the valve is on the discharge side of the fire pump and that the valve controls the line connecting the water system to the foam system.

The suction valve (T) enables the fire pump to draw water from an outside source. The control for the valve is manually operated from the pump compartment at the side of the truck. Note from the diagram of the system in figure 4-1 that water drafted through the suction valve is pumped on through the system the same as water pumped from the tank.

There are three outside discharge gates in the pump compartment for use with additional handlines or hoses. These discharge gates are equipped with manually operated shutoff valves. Figure 4-1 indicates that any time the fire pump is in operation, water is under pressure at these gates. Therefore, the

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valves should be closed and the lines capped when these discharges are not in use.

Exercises (856):

1. What action should you take to assure positive escape of the air while pressure filling the water tank on the P-2?

2. How many impellers are in the P-2's pump?

3. What is the secondary function of the relief valve on the P-2?

4. When should the relief valve handle be placed in the off position?

5. What are the inductors in the water system on the P-2 for?

6. How many strainers are there in the water system and where are they located?

7. What is the maximum elevation of the turrets on the P-2.

8. How do you flush the P-2's firefighting system?

9. Why must the three outside discharge gate valves be kept closed except when in use?

857. Explain the operation of the foam system on the P-2.

Foam System Unit. Components of the foam system in figure 4-1 include the foam tank (B), the foam pump (X), the pressure regulator (Y), the discharge valves (F), and the metering valves (G). As we discuss each of these, you should refer to the system diagram. Note that the foam piping in the illustration is coded with dotted lines. Also, we have inserted arrows to show you the direction of foam flow.

Foam tank. The foam tank, located behind the water tank, is made of fiberglass and can be filled through openings in the roof. Five-gallon foam cans, if they are used, are opened and drained into the foam tank by pressing the cans down on the special puncturing devices provided at the tank openings. As with the water tank, the rear-fill piping (A) can also be used to fill the foam tank from a pressurized source. Also, like the water tank, there is a float valve to close the lines when the liquid in the tank reaches the proper level, and a direct-reading level gage is mounted near the water gage and is operated in the same manner. A check valve, incorporated in the fill line near the top flange of the foam tank, prevents reverse flow in the system during filling.

A hydraulically operated foam suction valve (Z), controlled from inside the cab, is mounted just below the foam tank in the outlet line to the foam pump (X). The purpose of this valve, which can also be operated manually from the pump compartment in an emergency, is to close the line while the foam system is being flushed with water and to admit foam solution to the foam pump during foam discharge operations. If the valve is not completely open, you are likely to get a poor foam mixture. Referring to the system diagram, note that the suction valve is located above the point where the washout line connects to the foam pump feed line. Consequently, with the valve closed to keep water out of the foam tank and with the washout valve (R) open, water from the pump discharge can enter and flush the foam system.

Foam pump. Although the foam pump (X) is smaller, its operation is similar to that of the water pump. However, the piping and connections permit drawing foam solution only from the truck foam tank (B). The same gearbox is used to drive the foam pump from the pump engine. In fact, the foam pump, which is a single-stage centrifugal type, is mounted on this gearbox and driven from it through a clutch incorporated in the side of the gearbox. The clutch, which is a twin disc dry type, is operated by a hydraulic cylinder which obtains pressure from a hydraulic pump driven by the pump engine.

The foam pump is operated from the cab by means of a control valve which directs hydraulic pressure to the hydraulic cylinder to engage the pump clutch and, at the same time, causes the foam tank suction valve to be opened hydraulically. The pump engine should be engaged and all drain valves should be closed. As indicated in figure 4-1, the liquid foam discharges into two different lines, one to the roof turret and one to the bumper turret and handline, each of which is equipped with a pressure regulator. From here, the solution passes through the piping to the inductors (H), via the foam discharge valves, check valves, and metering valves. At the inductors, the liquid foam and water join and pass on out through the nozzles when their discharge valves are open and the pump engine is accelerated in order to obtain the desired discharge pressure. Following the foam operation, you should clear the system by turning off the foam control valve after returning the pump engine to idle speed. Then, with all discharge valves

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open, you should accelerate the engine until the discharge lines are cleared of foam solution. Finally, you should complete the job by flushing out the foam piping by use of the washout valve (R).

Pressure regulators. The purpose of the two pressure regulators (Y), or *proportioners,* as they are sometimes called, shown in the discharge side of the foam pump, is to sense pressure within the water and form piping and proportion or regulate the quantity of liquid foam according to the water pressure. In other words, they maintain the correct ratio between the liquid foam and the water by pressure sensing. The upper regulator shown in the illustration is actually the larger and serves the roof turret, and the other regulates the pressure for the bumper turret and the handline. Each regulator is equipped with two sensing lines (small copper tubing), as indicated in the diagram of the system. They are shown as solid black lines. These sensing lines, one of which is shown as E in figure 4-1, are necessary for proper functioning of the regulators. For flushing, there is a small tube with a petcock for each regulator.

Discharge valves. As indicated in figure 4-1, there is a foam discharge valve (F) in each of the three foam lines leading to the inductors. The purpose of these foam discharge valves, which in this system are operated by air pressure from the truck air system, is to open or close the foam lines as desired. For example, if you wish foam at the roof turret (M), you place the agent control for this nozzle in the FOAM position and operate the switch or lever that opens the discharge valve (K) for the turret. Movement of the switch or lever actuates a microswitch (L), which in turn operates a solenoid valve to admit air pressure to a small cylinder to open the foam discharge valve (F).

Between each foam discharge valve (F) and foam metering valve (G), there is a check valve (indicated by an arrow), or one-way valve, in the piping which permits foam solution to flow in only one direction. In other words, the foam passes freely through the piping toward the various discharge nozzles but cannot go back toward the pump. This process prevents the entry of water into the foam lines while foam is not being dispensed.

Foam metering valves. There are three foam metering valves (fig. 4-3) in the cab: one for the roof turret line (A), one for the bumper turret (B), and one for the handline (C). The valves are calibrated at the factory to deliver a specific amount of foam, based on a foam-to-water ratio expressed in percentage of foam in the total volume of foam-water mixture. The valves are set according to the truck manufacturer's calculations. For example, in the system under consideration, the metering valves are set and locked (by setscrews) to produce 6 percent foam; such a setting results in a mixture of 94 percent water and 6 percent foam. Ordinarily, this adjustment need not be disturbed. However, if you need to increase or decrease the amount of foam in the mixture, the control knobs of the valves can be rotated as necessary (after you have loosened the setscrews). Turning the knobs clockwise increases the foam (strengthens the mixture), whereas counterclockwise rotation decreases the mixture strength.

Exercise (857):

1. How is the foam tank filled?

2. What is the purpose of the foam valve and how is it operated?

3. Where does the foam pump get its power and how is it driven?

4. How many pressure regulators are there in the foam system and what is their purpose?

5. How many foam discharge valves are there in the foam system and how are they operated?

6. What must you do to increase the foam mixture strength for the roof turret?

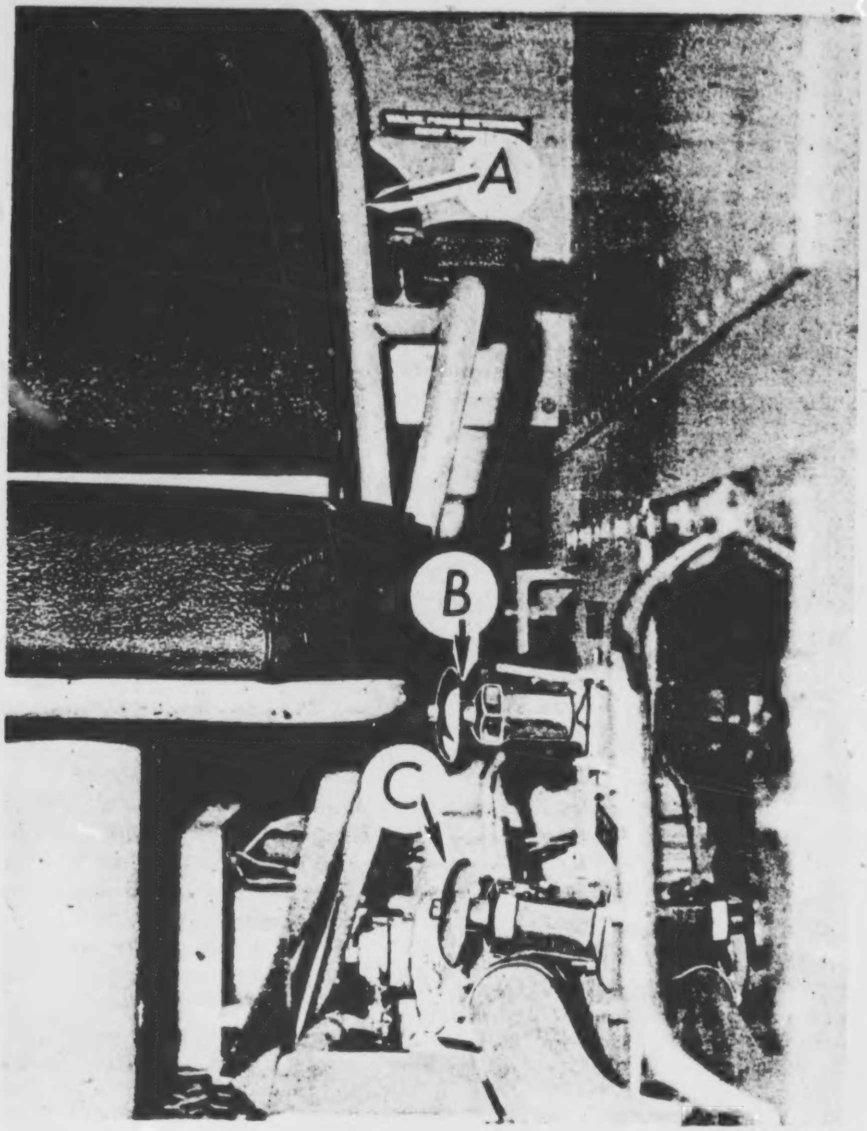
858. State and explain actions necessary to the operation of the agent discharging devices on the P-2.

The P-2 is a widely distributed aerospace firefighting truck. Its operation, like that of other firefighting and rescue trucks, is complex. Many hours of actual operation are necessary for you to achieve the required proficiency in handling this truck. From this text, you will be able only to familiarize yourself with the controls used to operate the truck.

As you read this text, refer often to the illustrations. If your fire department has a P-2, by all means use it as a reference for your studies. Always remember, if the actual equipment is available, use it. Apply this technique to all of your learning processes.

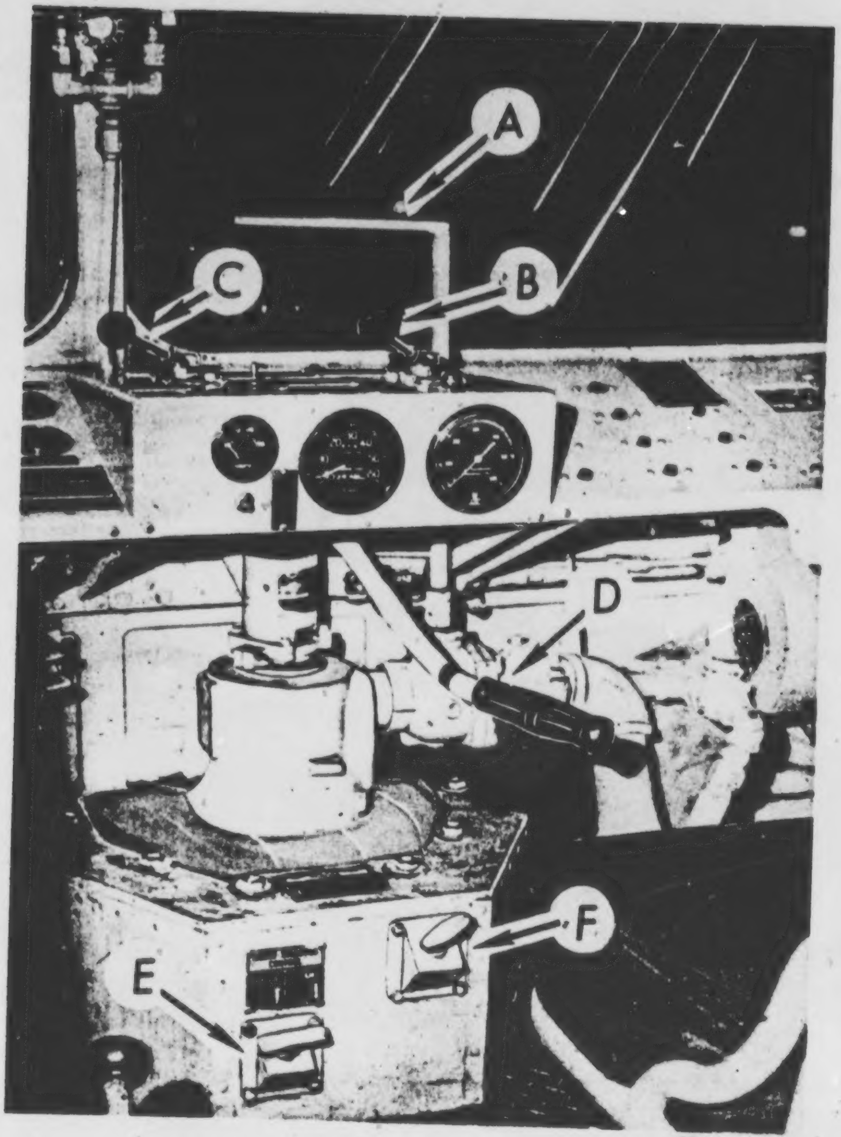
Roof Turret Operation. Normally, the roof turret is hydraulically operated by remote control. The hydraulic operation is much like the power steering of an automobile. Four nozzles are attached to the turret base. Each nozzle may be selected to discharge a foam and water solution or water only. Two of the nozzles are commonly called water nozzles, and the other two are called foam nozzles. All controls required for hydraulic operation of the roof turret are within easy reach of the operator.

The following is an example of a typical operation of a roof turret. Begin by engaging the water and foam pumps (items C and B, fig. 4-4). The turret may also be operated using water only by NOT engaging the foam pump. The turret hydraulic valve (fig. 4-5, item 10), should be closed. CAUTION: The turret hydraulic valve should be closed at all times unless air is to be bled from the hydraulic system. The decontrol valves (fig. 4-5, items 2 and 3) are pulled down to hydraulically control the turret. The turret operating handle, item 6 (fig. 4-5), is used to direct the movement of the turret to different positions. To direct the turret, push up on the operating handle to lower and pull down to raise it. The operating handle may be extended for increased leverage and ease of handling. The extended portion is spring-loaded and will retract when released. The discharge valve switch, item 4, will open the discharge valve electrically and start the discharge from the turret. The turret discharge may be stopped by pressing the stream interrupter switch, item 5. This switch is located on the end of the turret operating handle. When the



A. Roof turret metering valve
B. Bumper turret metering valve
C. Handline metering valve

Figure 4-3. Foam metering valve.



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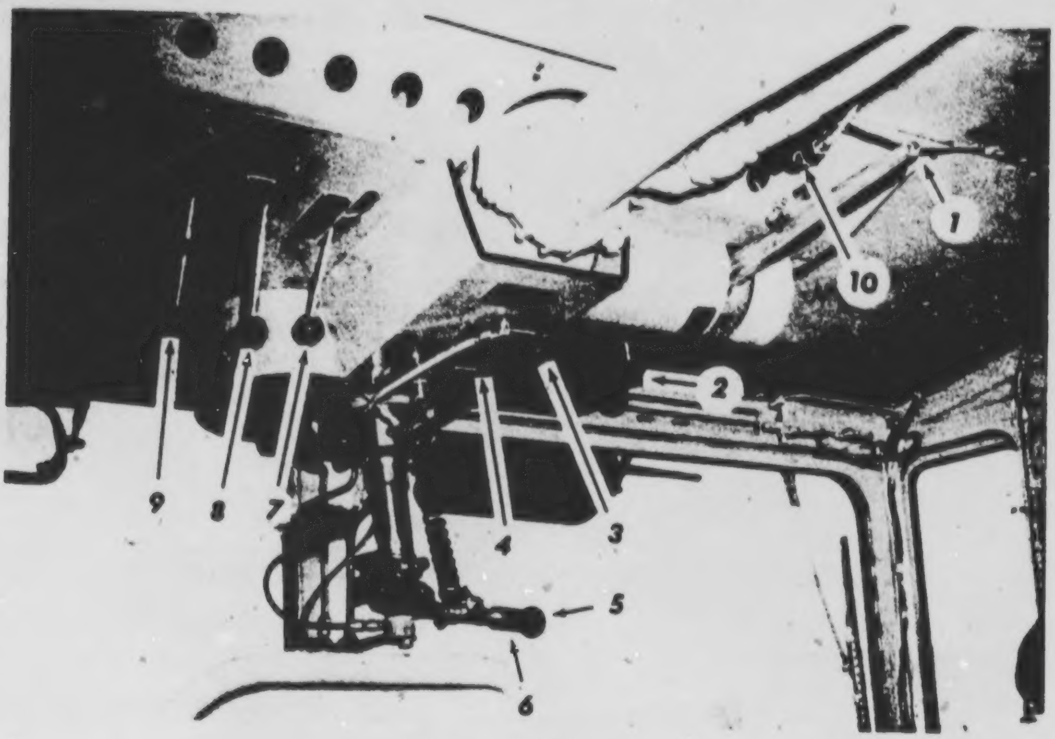
A. Bumper turret discharge control valve
B. Foam pump valve
C. Collector gear box shift control
D. Bumper turret control handle
E. Bumper turret agent selector control
F. Bumper turret dispersion control

Figure 4-4. In cab firefighting control panel.

switch is released, the discharge will again begin. If the electric switches, the discharge valve, and the stream interrupter fail to open the discharge valve, it may be manually opened.

The desired nozzles, either water of foam, are selected by moving the agent selector lever, item 8. You may select foam by moving the lever to the forward forward position, or water by moving the lever to the rear position. The discharge of agent from the turret must be interrupted before you move the rate control lever, item 9. This practice will prevent damage to the selector-plate valve and seals. The rate-control lever in the forward position will set the turret discharge at 500 gpm through one water nozzle and 1000 gpm through the foam nozzles. When the rate-control lever is moved to the rear position, the



1. Manual discharge valve lever
2. Manual discharge decontrol knob
3. Manual operation decontrol knob
4. Discharge valve switch
5. Stream interrupter switch
6. Operating handle
7. Dispersion control lever
8. Agent selector lever
9. Rate control lever
10. Hydraulic valve

Figure 4-5. Roof turret control panel.

turret is set to discharge 1000 gpm through the water nozzles and 500 gpm through one foam nozzle.

The dispersion control lever, item 7, when in the forward position, sets the turret to discharge solid streams from either the water or foam nozzles. As the dispersion-control lever is moved to the rear, the solid stream from the foam nozzle(s) will be gradually flattened to a fan pattern.

Be sure to store the turret properly after use.

If any part of the hydraulic pressure system of the turret fails, the turret may be operated manually. The turret is manually operated by remote control from within the cab. Only two changes are required for manual turret operation. First, the decontrol valves must be in the UP position. This will prevent any hydraulic pressure from reaching the turret controls. Second, the turret discharge valve is opened with the manual discharge valve lever, item 1. The manual-discharge control lever is released from its storage clip on the cab ceiling. The released handle will then swing down and forward to a locked position. The discharge valve is then opened by pushing the discharge valve lever forward. All other control valves are operated the same as previously mentioned for the hydraulic operation. To stop the manual turret operation, simply pull back on the discharge valve control lever. Store the turret properly. Return the discharge control lever to storage by moving the handle sideways to the right to unlock it and then swing it up into the clip on the cab ceiling.

Bumper Turret Operation. The bumper turret may be operated only by manual controls. These controls are located on or under the dash within easy reach of the driver or turret operation (see fig. 4-4). Two nozzles are attached to the turret base. One is called the water nozzle and the other the foam nozzle. (Bumper turret control items may be found in figure 4-4 from now on unless otherwise indicated.)

The following information is an example of a typical operation of a bumper turret. First, engage the water, item A, and foam pumps, item B. Use the bumper turret operating handle, item D, to manually position the turret as you desire. To select the water nozzle, pull up on the agent selector handle, item E, or push down on the handle to select the foam nozzle. The stream pattern is selected by pulling out or pushing in the bumper turret dispersion control handle, item F. A solid stream from either the water nozzle or foam nozzle may be selected by pulling out on the control handle. A flat fan pattern may be selected from the foam barrel or you can select a dispersed cone-shaped stream from the water barrel by pushing in on the control handle. NOTE: Discharge of agent in a solid stream from the water barrel must be interrupted before you select the dispersed cone-shaped stream from the barrel. If this is not done, damage to the gears may result. To begin discharging the agent, simply open the bumper turret discharge valve, item A. To end the operation, close the discharge valve and store the bumper turret.

Handline Operation. The handline compartment is located at the right front corner of the truck and can be reached only from the outside. The nozzle is equipped with a water nozzle and foam nozzle similar to those on the bumper turret. A solid stream may be selected from either of these nozzles. From the foam nozzle, you may select a varying degree of a flat fan pattern. You may select a cone-shaped stream or a variable, flat, fan-shaped stream from the water barrel. Be careful to interrupt the solid stream discharge from the water barrel before changing to the cone-shaped stream.

To place the handline into operation, first remove it from storage. While at the storage compartment, open the discharge valve found on the compartment wall. Select which nozzle you will use by moving the selector handle (on the left side of the nozzle) to the "F" position for foam nozzle or "W" position for water nozzle. You select the pattern of discharge from the foam nozzle by twisting the control handle mounted midway down the nozzle. You may select a variable flat fan stream or a solid stream. The pattern from the water nozzle is selected by manually moving the disperser or the deflector handle just to the left of the water nozzle opening. Placing the disperser in front of the nozzle will provide for a cone-shaped stream. If you move the deflector handle up or down, you get a variable, flat, fan-shaped stream. You control the direct discharge from the nozzle by a squeeze lever located just forward of the nozzle-to-hose connection. The amount of pressure exerted against the lever will determine the amount of discharge.

Exercises (858):

1. What is the first step in the operation of the P-2 roof turret?

2. How can you get more leverage on the roof turret control handle if it is in its normal position?

3. In what position would the three control levers (items 7, 8, and 9 of fig. 4-5) be if you are discharging 500 gpm through a water nozzle in a dispersed pattern?

4. Why must the agent flow be stopped when changing stream patterns on the roof turret?

5. What changes must be made to operate the roof turret manually from the hydraulic mode?

6. How do you stop the flow of agent from the roof turret on the P-2?

7. What are the steps to put the bumper turret into hydraulic operation?

8. How do you get a flat fan foam pattern from the P-2 bumper nozzle?

9. Where is the bumper turret discharge valve control handle located?

10. How do you control the direct discharge from the P-2 handline nozzle?

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859. Give pertinent instructions for pumping operations using the 4½-inch intake on the P-2.

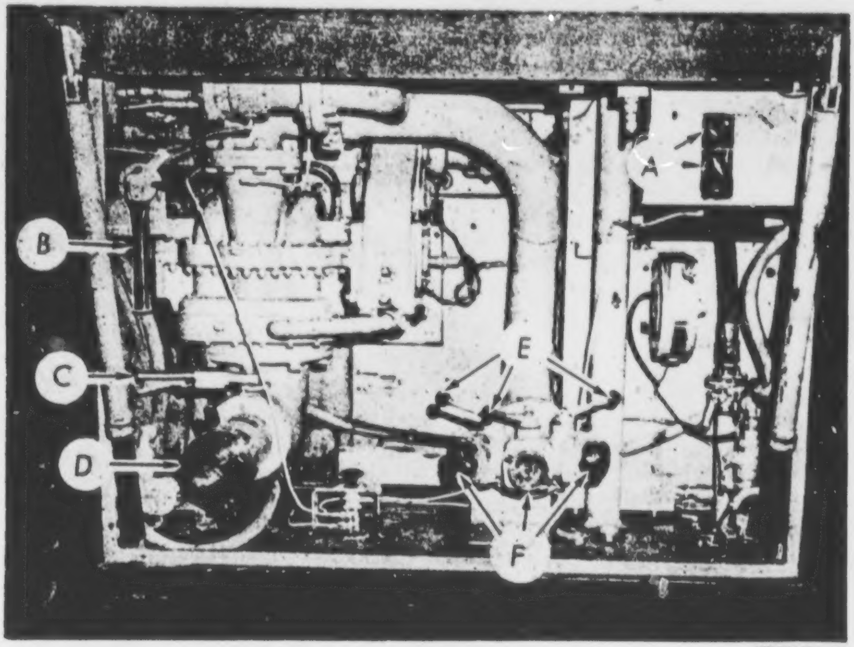
Pumping From a Hydrant or Relay. With the pumping capability of the P-2, do not attempt to pump more water than is available from a hydrant or a relaying pumper (nurse truck). Always make sure the pump pressure gage stays above zero.

Before engaging the water pump close the water tank suction valve by placing the control, item B, figure 4-6, in a horizontal position. Connect a 4½-inch suction hose between the hydrant or relaying pumper and the intake (fig. 4-6, D) and open the intake valve by placing the handle (fig. 4-6, C) in position parallel to the inlet. Engage the water pump using the same procedures as outlined earlier in turret operation.

Open the discharge valves for the dispensing devices being used and accelerate the pump engine, using the hand throttle located in the cab to the left of the pump controls on the dash near the driver's right leg, until desired pump discharge pressure is obtained. When 2½-inch hose is to be used, you must remove the 2½-inch discharge outlet cap(s) (fig. 4-6, F), connect the desired number and length of hose (with nozzle), and open the discharge valves by placing the handle (fig. 4-6, E) parallel to the outlet being used. NOTE: Foam cannot be discharged through the 2½-inch hoses from the installed foam systems.

Pumping from Suction (Drafting). Make certain that all drain valves are closed before you engage the pump. Check the setting of the pilot valve (fig. 4-6, A) and close the water tank suction valve by placing the control in a horizontal position. Place the truck as near as possible to the water supply. Connect a 4½-inch suction hose to the inlet on the fire pump. In placing suction hose, avoid humps or sharp bends. Make certain no part of the hose is higher than pump suction inlet or air pockets will form. Immerse the suction strainer at least two feet below the surface of the water to prevent the pump from drawing air. Whirlpools forming above the suction strainer indicate that the strainer is too close to the surface of the water. Make certain that the strainer is far enough from the bottom to prevent pumping sand, gravel, or other foreign matter. Sharp sand and gravel in the drafted water may seriously impair pump efficiency and service life.

Open the suction valve by placing the handle in the position parallel to the inlet. Place the relief valve (fig. 4-6, A) in the OFF position. Prime the water



A. Relief valve control (top) and pilot valve control (lower)
B. Water tank suction valve control
C. 4½-inch pump inlet valve handle
D. 4½-inch pump inlet
E. 2½-inch discharge valve handles
F. 2½-inch discharges

Figure 4-6. P-2 pump compartment controls.

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pump; the water pump must be primed prior to operating from a suction. Priming is not required for other types of operations. To prime the water pump, close the discharge valves, drain valves, and all other openings. Make sure the suction connection is tight. Open the priming valve by pulling out its handle. The priming pump motor will start when the priming valve is fully open. Allow the priming pump to run until it emits a solid stream of water through its discharge pipe. If the priming pump does not begin to discharge a steady stream of water within one-half minute, close the priming valve and check for air leaks. Also, make sure oil from the priming tank is reaching the priming pump properly. Upon completion of priming, close the priming valve and immediately engage the water pump. Open the discharge valves for the dispensing equipment being used and accelerate the pump engine, using the hand throttle, until the desired pump pressure is obtained. The preceding information is for a drafting operation using early models of the truck.

On P-2's not equipped with a water pump priming system, about the only way you will be able to prime the pump is by "dumping" the water tank. To do this, you must make your hookup with the suction hose as outlined before. Then, instead of closing the water tank suction valve, you open it and open the 4½-inch intake valve to allow water to "backflow" (gravity flow) from the water tank through the water pump and suction hose into the drafting source.

Keep a close watch on the area where the 4½-inch suction enters the water source for signs of the water from the P-2 water tank entering the drafting source. This is normally indicated by air bubbles forming as the air is forced from the suction hose. When the air is out of the hose, the surface of the drafting source may show a slight "rolling" motion. When this rolling motion is noted, or a few seconds after the last air bubbles are noted, you should engage the water pump to draft as outlined before.

Exercises (859):

1. When pumping from a hydrant or relay, the pump pressure gage must stay above what pressure?

2. What must be done before the water pump is engaged when pumping from a hydrant?

3. How do you accelerate the pump engine to the desired pump pressure while pumping from relay?

4. In what position must the tank suction valve be for drafting with the P-2?

5. What will happen if any part of the suction hose is higher than the pump suction inlet?

6. Why must the strainer be kept far enough from the bottom of the water source to prevent suction of foreign matter?

7. In what position is the relief valve placed for drafting before the water pump is primed?

4-4. The A/S32P-4 Fire Fighting Truck

The Air Transportable Multipurpose Fire Fighting Truck, Type A/S32P-4, is designed to provide quick-response fire suppression capability for control of aircraft crash fires, real material and property fires, and rescue of entrapped personnel under a wide range of climatic conditions. The firefighting system is entirely self-contained in that it requires no outside source for extinguishing agents (water and foam); these are carried in storage tanks mounted inside the vehicle body. Extinguishing agents may be delivered through either of the two cab-mounted turrets or the handline individually or simultaneously. The chassis design provides for maximum flexibility in deployment of the firefighting system in adverse conditions of terrain and climate. The firefighting system provides the means for pumping from a hydrant or draft water supply in structural fire fighting operations.

The vehicle is air transportable by C-130 aircraft. Removal of the roof turret and piping, overhead projections, the warning light, and repositioning of the rear spotlights and rear view mirrors is required in order to gain sufficient overhead and side clearance for loading into the C-130 hold. Lifting and tie down rings are provided at appropriate points on the vehicle frame for securing to the floor of the aircraft cargo compartment. The air transportability and mobility of the vehicle in adverse conditions make this equipment especially suited for the bare-base concept of operation.

860. State construction characteristics of, and locate components on, the P-4 multipurpose fire truck.

Cab and Body. The personnel cab and the vehicle body are fabricated of aluminum and are fully insulated to prevent heat loss from the vehicle interior during operation in colder climates and prevent freezing of the water in the firefighting system. The insulation is fire resistive to protect the interior and occupants from the radiant heat of a blaze at a close proximity to the vehicle, during frontal approach to the fire. A complete winterization system makes the vehicle operational at temperatures as low as -40° F.

The cab provides comfortable seating facilities for a crew of up to four members and provides a complete complement of controls and instruments necessary to effectively direct and monitor the performance of the vehicle and the firefighting system during crash truck operation. Grab bars are provided to assist personnel during rough terrain operations, and seat belts conforming to MIL-B-8607 are firmly anchored to the cab floor at each seat location.

A cab heater is provided for use in colder climates, and an air conditioning system will maintain a comfortable environment for the crew in the warm and humid climates. Windshield defrosters, with variable speed blowers, are installed to keep the windshield clear of mist and ice. An escape hatch is provided in the cab roof, for use by the crew if the doors become damaged and inoperable. This hatch is adequately sealed to prevent the leakage of water into the cab during rains and firefighting system operation.

The vehicle body encloses the chassis and drive line components as well as the firefighting system, and provides storage and mounting for vehicle accessories and components of the KMK/S32P-4 Structural Firefighting Kit. Hinged panels are provided for access to all mounted equipment and maintenance points. The body is mounted in two sections, the center body and the rear body, separate from the cab. This design allows for maximum articulation of drive line components and frame deflection without placing undue stress on the body and sheet metal coverings.

Chassis. The chassis is arranged as a 6x6 all wheel drive, with rear engine mounting. The engine is a 6-cylinder diesel, of adequate power to provide mobility to the vehicle as well as to furnish the power to drive the foam and water pumps. The engine is coupled to a power divider which has three output shafts, one for the vehicle drive line and one for each of the pumps (water and foam).

The drive line consists of a power divider hydraulic torque converter and six speed power shift transmission, single speed transfer case, single front driving axle, and tandem rear driving axles. Each axle is equipped with a locking differential for improved traction under icy or muddy conditions. Power assisted service brakes are mounted on each axle.

Engine. The engine is a 4-cycle diesel, in-line 6-cylinder, turbocharged and after cooled, with 425 maximum brake HP at 2100 rpm. The engine is mounted at the rear of the chassis with the flywheel end facing forward. Through belt drives and mechanical connections, the engine furnishes the power to drive the vehicle and operate all vehicle accessories. Quick disconnects are provided on all hydraulic, fuel and water lines and on all electrical wiring to facilitate quick removal of the engine-power divider package.

The engine cooling system is connected into the winterization system of the vehicle. The winterization system will maintain engine coolant at near operating temperature to facilitate starting in cold weather. In addition, glow plugs in each cylinder for preheating the combustion chamber are also installed as cold weather starting aids.

Power divider. The power divider is mounted on the flywheel housing of the engine and serves to split the engine drive into three separate drives: the water pump drive, the foam pump drive, and the main drive to the vehicle transmission. In addition, the power divider provides mounting and drive arrangements for the modulating clutch oil pump. This pump circulates oil through the power divider to dissipate the heat generated by clutch operation.

An amber warning light system is provided on the cab instrument panel and structural control panel to advise operating personnel of insufficient air pressure for proper pump clutch engagement and/or insufficient oil pressure for pump engagement.

The drives to the foam and water pump clutches are direct mechanical drives; they are always running when the engine is operating, and their speed is controlled by the speed of the engine. A separate air actuated clutch is provided in each pump drive as a means of disconnecting the pumps when they are not in use. The drive to the main transmission is controlled by the modulating clutch (a large clutch bolted to the engine flywheel). This clutch may be "modulated" (operator controlled slippage) whenever the pump clutches are engaged with the transmission in any gear. The clutch will be modulated whenever vehicle drive line torque and speed requirements are necessary to maneuver the vehicle.

Transmission. The transmission is a six-speed semi-automatic (power-shift) type with a built-in torque converter. The transmission is of the horizontal shaft design, using constant-mesh gears and oil cooled and oil actuated multiple disc clutches. The transmission is controlled by the operator from a shift control in the cab, through a cable to the transmission control valve linkage. An output shaft parking brake, of the internal expanding shoe type, is mounted on the rear of the transmission and actuated by air pressure, controlled from a valve in the cab.

Transfer case. The transfer case is mounted just forward of the transmission, and serves to provide two output yokes (one for the front axle, one for the rear axle) for transmission of power from the transmission output shaft to each of the axles simultaneously. An automatic center-locking differential mechanism is provided between the front axle output shaft and the rear axle output shaft to provide for some difference in front axle speed and rear axle speed (as when negotiating turns). This differential is of the locking type, which automatically provides for full torque application to both axles simultaneously under conditions where one wheel or axle may lose traction and tend to spin. An oil pump, driven from the input shaft, provides positive bearing lubrication for the input and output shaft bearings. The transfer case provides the oil sump for the lubricating oil, and the gears are splash-lubricated from the internal sump.

Brake system. The brake system is an air-over-hydraulic type system, where air pressure is used to provide a power boost for the vehicle operator's braking effort. The system is a dual or split system; front and rear axle systems are separate so that a failure in one system does not result in complete loss of braking action. Major elements of the brake system are the treadle valve, the power clusters, and the wheel cylinders. The treadle valve, mounted in the cab, is actually two air control valves in a single housing. Control of both valves is accomplished by depressing the single foot pedal. When the pedal is depressed, air pressure is transmitted simultaneously through separate circuits to the front and rear power clusters. The amount or degree of this air pressure is determined by the braking effort applied at the pedal. The power clusters are large diameter air cylinders mounted to a hydraulic master cylinder. The air pressure applied to the power cluster causes the air cylinder piston to move, actuating the master cylinder. The difference in size between the large air cylinder piston and the small master cylinder piston multiplies the brake application pressure many times. The hydraulic pressure from the master cylinder in the power cluster is transmitted to the wheel cylinders, where it causes the wheel cylinder pistons to extend and force the brake shoes into contact with the rotating drums.

Parking brake. A drum-type output shaft parking brake is used on the vehicle, mounted on the transmission output shaft. An air brake chamber connected to the brake actuating lever provides the means for remote operation of the brake. The air chamber is of the fail-safe type, where loss of air pressure in the brake system allows a large spring built into the chamber to apply the parking brake automatically. A release bolt built into the chamber provides a means for retracting the spring if the air system cannot be pressurized. The operating controls of the parking brake are independent of the operating controls of the service brakes.

Air system. The air system consists of an engine-driven compressor and four air pressure storage reservoirs, together with the necessary valves and plumbing to supply and control the various air operated devices on the vehicle. Air, under pressure from the compressor, flows first through a safety valve and alcohol injector, to one small reservoir, where pressure builds up to a level sufficient for safe operation of the brake system. Once this level is reached, a pressure regulator in the system opens to allow the remaining reservoirs to be pressurized. All air operated components operate from the air supply in these two larger reservoirs until the pressure drops to a predetermined level; then, the brake system has priority. The reason for this "two stage" type of system is to allow a rapid buildup to pressure for safe operation of the brake system, since the truck cannot be moved until this pressure is adequate. A governor on the compressor senses pressure in the system and cuts out compressor operation when normal operating air pressure is reached, and starts compressor operation whenever system pressure falls below this figure. In addition, a warning system, consisting of a pressure switch and electrical buzzer, will actuate whenever air pressure falls to a point where the brakes cannot be operated safely. Components or systems requiring air pressure for operation are listed below:

a. Service brakes (treadle valve to power clusters).
b. Engine (governor and throttle control).
c. Cooling system (radiator shutter control).
d. Transmission (shift lock cylinder).
e. Parking brake (air chamber actuator).
f. Windshield wipers (air motor).
g. Windshield washers (pressurized reservoir).
h. Pump clutches (air chamber).
i. Modulated clutch (air chamber).
j. Front hose reel (rewind air motor and purging).
k. Air horn.
l. Agent system valving (air cylinder operators).
m. Differential lockout (air cylinder operators).

Electrical system. The electrical system operates at 24 volts, supplied by four 12 volt batteries connected in series-parallel. A 28-volt engine driven alternator supplies the current to maintain the battery charge while the engine is running. Current from the alternator is rectified internally and alternator output is controlled by the voltage regulator, according to the system requirements. The slave receptacle may be used to maintain battery charge while the truck is on standby by connecting a power cord from a 120 VAC supply. A built-in power supply, with rectifier and reverse current protection, will furnish 28-volt, 35-ampere current to the vehicle electrical system for operation of accessories (such as the winterization system) and maintenance of battery charge. Electrically operated components and vehicle accessories include headlights, taillights, directional signals, spotlights, floodlight, cab interior and compartment lighting, winterization system heater, pumps and blowers, engine starting motor, agent system solenoid valves, emergency beacon and siren, gages, instrument senders and warning devices, air conditioner blowers and thermostats. All major circuits are protected against overloads by automatic reset type circuit breakers, grouped on a common panel and located in the cab.

Winterization system. The winterization system provides the vehicle with operating capability at temperatures as low as -40° F. The system consists basically of a 90,000 BTU-diesel fuel burning heater in a piping system which circulates the heated coolant around and through the vehicle engine coolant system, cab heater, the various storage compartments in the vehicle body structure, and back through the engine oil pan to the booster heater. Finned-tube heat exchangers in the various compartments radiate heat from the heated coolant supply to maintain compartment temperature above the freezing point of water. A recirculating pump is provided in the system to maintain a constant flow of heated coolant to all parts of the system.

A second system within the vehicle consists of a pump and piping to recirculate agent system water through a heat exchanger where it draws heat from the primary system, through the discharge piping, the water tank, water pump, recirculating pump, and back to the heat exchanger. Operation of the winterization system is intended primarily for standby operations and requires that either the main engine be running, or the auxiliary power supply be connected to a remote source to avoid excessive drain on the vehicle's batteries.

Booster heater. The booster heater is a 90,000 BTU capacity, fuel-burning unit, mounted on a slide-out tray in a compartment on the right side of the vehicle. Engine coolant is circulated through the water jacket and heated by the burning mixture of diesel fuel and air inside the combustion chamber. Fuel for heater operation is drawn from the vehicle fuel tank by an electric fuel pump on the heater. The heater assembly includes an ignition assembly and combustion air blower which operate on 24 VDC supply. The heater fuel pump and blower are driven by the same motor. Thermostatic switches installed in the water jacket monitor coolant temperature and cycle the heater as required to maintain coolant temperature in the range of 180°F to 200°F. An overheat switch will shut down heater operation in the event the cycling switch fails and heater continues to operate at temperatures above 215°F. In case of ignition failure, an automatic mechanism will shut down the heater, to prevent accumulation of unburned fuel in the combustion chamber. Controls for the operation of the heater are located in the cab, and include a malfunction indicator light, which illuminates whenever the heater shuts down because of overheat or ignition failure.

Fuel system. The fuel system consists of a 40-gallon capacity diesel fuel tank, located on the left side of the vehicle at the approximate mid-point of the chassis, plus the necessary piping, valves, and fittings to deliver the fuel to the vehicle engine and booster heater. A separate set of fuel lines is provided for the booster heater, and for the engine. Each component has its own fuel pump which delivers fuel at the rate and pressure appropriate for the unit. At the engine the fuel passes through the primary fuel filter, then secondary filters, and is delivered to the fuel injection pump. Within the injection pump, separate plunger type pumps for each cylinder meter the exact amount of fuel required by the engine and deliver it, under very high pressure, to the fuel injectors. Any excess fuel passes through a bypass line from the injection pump housing back to the fuel tank. The booster heater, like the engine, contains its own fuel filter and pump, so that each unit is entirely independent of the other. The fuel tank provides a drain for the removal of condensation and sediment from the system.

Air conditioning system. The air conditioning system is installed to provide a comfortable environment for the crew when operating the vehicle in very hot or humid conditions. The system consists of the condenser/evaporator unit, mounted in a compartment just behind the cab on the upper left side of the body; the compressor, which is mounted on a bracket to the left of the engine; and the controls, which are located on the air conditioner ducts on the back wall of the cab. The air conditioner will not cool down rapidly as will one in a passenger car. As long as 45 minutes may be required, under extreme conditions, to reach an 85°F temperature inside the cab.

Exercises (860):

1. How many engines, of what type fuel, provide power of operation of the drive train and running gear?

2. What provisions are made for crew exit in case the cab doors become damaged or inoperable?

3. How are the chassis and engine arranged?

4. What are the three output shafts from the power divider for?

5. What provisions are made for quick removal of the engine power divider package?

6. How can operating personnel tell if there is insufficient air and/or oil pressure for proper pump clutch engagement?

7. What do we mean by the word "modulated" when we refer to a "modulated clutch"?

8. What type of transmission does the P-4 have?

9. What is the purpose of the automatic center-locking differential mechanism?

10. What is an air-over-hydraulic type brake system?

11. Where is the parking brake mounted and what does the fail-safe air chamber do?

12. How many air pressure storage reservoirs are there in the P-4 air system?

13. What is the reason for the "two-stage" type of air system on the P-4?

14. How will you know when the air pressure falls to a point where the brakes cannot be operated safely?

15. At what voltage does the electrical system on the P-4 operate and how is this voltage supplied?

16. What is the capacity of the booster heater on the P-4 and type of fuel used in it?

17. The booster heater maintains the coolant in the range of ______°F to ______°F.

18. How much fuel will the fuel tank of the P-4 hold and what type of fuel is used?

19. Where is the air conditioning condenser/evaporator unit mounted?

861. Give operating characteristics of the firefighting system and state the use of various equipment on the P-4.

Firefighting System. The firefighting system consists of the agent storage, plumbing, and discharge facilities. Storage is provided by foam and water tanks, constructed of fiberglass, centrally located within the body. The tanks provide two separate compartments, having capacities of 1500 gallons of water and 180 gallons of foam concentrate, respectively. A separate, engine driven pump is provided for water and for foam concentrate. The piping arrangement provides for delivery of water or foam only to the roof mounted discharge turret, bumper turret and handline, simultaneously or individually in any combination. The roof turret has a discharge capacity of either 400 gallons per minute (gpm) single barrel rate, or 800 gpm double barrel rate, as selected by the operator. The bumper turret discharge rate is 300 gpm, whereas the handline foam discharge rate is 50 gpm water and 100 gpm foam, using foam in accordance with Federal Specification O-F-555. (Specified rates are for unexpanded foam.) Provisions are made within the agent piping system for hook-up to a hydrant supply, and for pumping from draft during structural firefighting operations. The necessary hoses and couplings for completing these hook-ups are provided in the KMK-391/S32P-4 Structural Firefighting Kit. A system of valves within the agent system, under control of the equipment operator by means of pneumatic actuators, provides for flushing with water after use.

Engagement of the firefighting pumps is possible with the truck in motion, at any speed up to 60 mph, and continued vehicle operation at speeds up to 10 mph on level concrete is possible with all agent system nozzles discharging at full rated capacity. This feature is made possible by the use of a modulating (slipping) clutch in the power divider. The power divider is so constructed that the pumps are driven (when the clutches are engaged) directly from the engine, and will always receive the speed and torque necessary for full capacity operation. Any excess of engine torque under the varying operating conditions is transmitted to the vehicle driveline by the modulating clutch, under control of the foot throttle.

Water pump. The water pump is a single stage double-volute balanced thrust type, driven from the pump transmission. A clutch on the power divider engages and disengages the drive to the pump transmission, and is controlled from inside the cab or from the structural control panel. The pump consists of an upper and lower body assembly and an impeller shaft assembly. The bodies divide into two passages to conduct water to the suction eye on each side of the impeller. The impeller shaft provides an input yoke at one end for coupling to the drive shaft, and consists of the double-suction bronze impeller, the stainless steel impeller shaft, wear rings, packings, and ball bearings for support of the shaft at either end. Stuffing boxes are provided in the housings for easy adjustment and replacement of packings to control leakage.

Foam pump. The foam pump is a single-stage centrifugal pump, mounted on the power divider. The main components of the pump are the gear case assembly and the body and impeller shaft assembly. A clutch in the power divider engages and disengages the drive to the foam pump as required, and is controlled from inside the cab.

The gear case assembly includes all the parts which transmit power from the power divider to the pump impeller. The gear ratio has been selected to closely match impeller shaft speed to pumping requirements.

The body and impeller shaft assembly includes the impeller, shaft bearings, driven gear, body, head, and related parts. The shaft is ball bearing supported and the impeller dynamically balanced to keep vibration at a minimum. A stuffing box is provided in the housing for easy adjustment and replacement of packings to control leakage.

Valve and piping. All necessary valving and piping is provided to enable the system to operate under numerous firefighting and climatic conditions. Pressure regulator and relief valves, with bypass lines, are installed in the system to maintain operating pressure. Foam pressure is controlled by a pilot operated regulator and is always in proportion to the water pressure, thus providing the correct solution under a variety of conditions. Foam concentrate and water are carried to each of the discharge points in separate lines, and are mixed in venturi inductors before discharge. Shutoff valves are provided in each foam line for the roof turret, bumper turret, and handline. These valves are open only when the agent selector valve is in the FOAM position, or when flushing the foam system. Drains are provided at appropriate draft or hydrant connections. All piping and valves are constructed of brass, bronze, or stainless steel for maximum corrosion protection.

Roof turret. The roof turret provides two foam barrels which may be operated singly or together, also two water nozzles that may be operated singly or together as determined by the equipment operator. The capacity of the turret is 400 gpm (single rate) or 800 gpm (double rate). Controls are provided in the cab for selection of single rate or double rate discharge, control of discharge pattern from solid stream to dispersed, foam barrel shutoff (for water discharge only), main shutoff (when turret is not in use), discharge interrupt, and turret aiming and positioning. The turret aiming is accomplished using a lever handle mounted to the turret control panel. This handle is connected through a linkage to move the turret in the desired direction, horizontally up to 105° either side of center, and vertically to 70° elevation through 20° depression from horizontal. Movement of the turret is hydraulically assisted by fluid pressure supplied from a pump on the water pump transmission. This hydraulic system is an entirely separate system from any other on the vehicle. Provisions are made for complete manual control in the event of hydraulic system failure.

Bumper turret. The bumper turret is a remote, manually operated turret mounted in front of the cab. It is designed to discharge water or foam at a rate of 300 gpm. Limits of movement in the horizontal plane are 85° each side of neutral and 45° elevation and 15° depression from horizontal. The depression is calculated to provide effective coverage at a distance of 20 feet from the front of the truck when used for groundsweep. The turret is used for groundsweep when approaching an emergency through flames. The bumper turret has a separate locking system independent from the bumper turret control system. This system includes a hook-type latch on the turret bracket to secure the turret in stowed position. Operation of the hook latch is accomplished by a separate control cable, with suitable hardware and brackets, connected to a bumper turret lock/unlock lever, mounted inside the cab, adjacent to the bumper turret control handle. As a feature of the bumper turret lock/unlock lever and its location in the cab, it prevents movement of the bumper turret control handle until the bumper turret is unlocked and free to move. Guides, to limit movement of the bumper turret, are located on cab frontal area, right and left sides. These prevent possible vehicle damage or hangup of the turret during operation. Design is such that the turret requires no movement of controls other than unlocking, initial positioning, and opening of the discharge valve when being used for groundsweep.

Handline. The handline consists of three 50-foot lengths of 1¼-inch diameter hose coupled together to provide 150 feet of handline, mounted on a reel at the front center of the vehicle, in a compartment under the cab. The handline has a maximum discharge capacity of 100 gpm. An air motor provides for powered rewind of the handline, and an automatic brake is provided to prevent overrunning of the reel. A hand crank is provided for rewinding hose in case of rewind motor failure. An air purging system, connected into the handline piping, allows for blow down of the hose after use. The handline nozzle is stored in a separate compartment at the right front corner of the cab, but remains attached to the hose and ready for use while stored.

Water priming pump. For pumping from draft, a means must be provided for priming the water pump through the 5-inch manifold on which the pump is mounted. This is accomplished by use of the priming pump. The priming pump is an electric motor driven pump which is used to partially evacuate air from the 5-inch manifold, thus allowing atmospheric pressure to push the water up into the manifold and pump suction chamber. Oil is used in the priming pump to provide lubrication and a hydraulic seal and enables the pump to operate as a vacuum pump. The oil is supplied from a 6-quart reservoir located in the compartment.

Auxiliary fire fighting equipment. In addition to the equipment permanently mounted to the vehicle, certain detachable or separate equipment has been provided with the vehicle, consisting of hand tools and rescue equipment as outlined below:

1 Axe
2½-inch female hose connectors
1 2½-inch gated coupling
2 2-gallon fire extinguishers (Serial Nos. below 13153)
2 30-pound dry chemical fire extinguishers (Serial Nos. 13153 and above)
1 21-foot folding aluminum ladder
1 Crowbar

1 Claw-type door opener
2 Adjustable hydrant and spanner wrenches
1 Gasoline engine driven metal cutting saw kit, with extra blades
1 Electric lantern
1 Pike pole
1 Bolt cutter

Exercises (861):

1. What are the capacities of the agent tanks on the P-4?

2. What is the maximum rate of discharge for the turrets on the P-4?

3. What is the maximum speed at which the fire fighting pumps on the P-4 may be engaged?

4. How is the water pump transmission on the P-4 engaged?

5. What is the stuffing box on the foam pump for?

6. How is the foam pressure on the P-4 controlled?

7. The roof turret of the P-4 has a maximum horizontal movement to the left of ______° from center.

8. The P-4's roof turret has a vertical movement of ______° from horizontal; ______° elevation and ______° depression.

9. How is the bumper turret on the P-4 operated?

10. The bumper turret on the P-4 can be moved a total of ______° horizontally and ______° vertically.

11. When is the bumper turret used for groundsweep?

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12. What provisions are made to prevent possible damage to the vehicle or hangups caused by the bumper turret on the P-4?

13. What size is the manifold on which the water pump is mounted?

14. What is the capacity of the oil reservoir for the water priming pump?

15. What size is the ladder on the P-4?

862. Locate controls and state recommended practices for mobile operation of the P-4.

Operating Equipment. Mobile operation of the vehicle is in many ways very similar to that of a similarly equipped conventional diesel truck. The vehicle is equipped with hydraulic power steering, power-assisted hydraulic brakes on all wheels, and a power-shift transmission. All controls and instruments necessary for mobile operation are grouped within easy reach of the driver's normal seated position.

Prestart checks. Prior to operation at the beginning of each shift, check the following items:

a. Evidence of leakage of oil under vehicle.
b. Obvious physical damage.
c. Engine oil level.
d. Engine coolant level.
e. Fuel level.
f. Tire pressure. Also check for cuts or foreign objects lodged in tires.

Starting the Engine. You must be very careful when operating the P-4 because it is a much different vehicle from the others we have discussed. To start the engine you should follow these steps in the order given.

a. Place chassis electrical master switch in ON position.

b. Make certain that the transmission gear selector is in neutral, N, position and parking brake knob is pulled out.

c. Turn the engine shutdown switch to ON position. If brake system air pressure is low, the warning buzzer will sound. Continue with the starting procedures as outlined below. The buzzer will shut off after the engine has started and brake system air pressure builds up to 65 psi. Do not attempt to drive the vehicle while the low pressure warning buzzer is sounding.

d. Depress the turn heat/start switch to START position while holding the throttle pedal in approximately half-speed position. An oil pressure

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actuated stop within the engine governor limits movement of the governor control linkage in a direction to increase engine speed until normal operating oil pressure has built up.

e. If the engine does not fully start within 10 seconds, turn and hold the engine master switch in the SHUTDOWN position until the engine stops firing. Return the master switch to the ON position and turn the heat-start switch to the HEAT position for 30 seconds. Repeat step d to start the engine.

f. If the starter disengages before the engine starts, release the heat-start switch and wait until the engine stops firing before returning the heat-start switch to the START position. Do not operate the starter continuously for periods of longer than 30 seconds. After cranking for 30 seconds, allow the starter to cool for 2 minutes before again attempting to start the engine. If, after several attempts, the engine will not start, consult the Table of Malfunction Analysis and Remedial Action in Section VI of TO 36A12-12-14-1.

g. After the engine starts, reduce the engine speed to idle until the oil pressure gage indicates normal oil pressure (45 to 60 psi).

h. During normal operations, run the engine for five minutes at 800 to 1000 RPM before applying a load, and observe all gages for normal indications. During emergency operations, it is necessary to wait only until the low air pressure warning buzzer shuts off before you drive the vehicle.

i. For starting and operating procedures in temperatures below 40° F, refer to TO 36A12-12-14-1.

Driving the Vehicle. After you check all gages for normal indication, operate the vehicle as follows:

a. Release the parking brake by pushing in control knob.

b. Depress the brake pedal. Make certain that the engine has returned to low idle speed before you shift into gear. During structural mode operation, the gear selector will be locked in the neutral position as long as the structural panel controls are activated.

c. Place the transmission gear selector in the gear range desired. The transmission is of the "powershift" type. Gear ranges must be selected by the operator because no automatic shifts can be effected. The vehicle will start and accelerate from a standstill in 3rd gear. It is recommended that 1st and 2nd gear be used only for off-road operations and ascending grades as necessary.

d. After starting in the desired gear range by depressing the throttle, accelerate to the following vehicle speed; then upshift to the next higher gear range.

1st	10 MPH
2nd	14 MPH
3rd	20 MPH
4th	28 MPH
5th	40 MPH

Do not allow engine speed to fall below 1500 RPM between shifts, as this will result in engine "lugging," overheating, and poor performance. Do not downshift at speeds above those listed for each gear, or engine overspeeding and drive train damage will result.

e. If the following vehicle speeds cannot be reached or maintained in the selected gear range with the throttle fully depressed, downshift to the next lower gear.

6th	40 MPH
5th	28 MPH
4th	30 MPH
3rd	14 MPH
2nd	10 MPH

f. When descending a grade, keeping the transmission in a lower gear range will aid in retarding vehicle speed. However, when using the engine to retard vehicle speed, pay careful attention to the tachometer reading to ensure that engine speed does not exceed 1800 RPM. Apply brakes as necessary to maintain engine speed below 1800 RPM. When slowing or stopping the vehicle on level ground, DO NOT downshift to aid in braking.

Operating on a downhill grade as explained above, can result in rapid heat build-up in the transmission fluid. Observe transmission oil temperature gage carefully and do not allow oil temperature to exceed 250° F. Shift to a higher gear range if heat build-up is excessive.

Differential lockout operation. Differential action in the axles permits one wheel to turn faster than the opposite wheel when negotiating corners or rough terrain to prevent tires from dragging or scuffing. However, this action will also allow one wheel to spin or lose traction altogether whenever icy or muddy conditions are encountered. The differential lock control may be used under such conditions to lock out differential action and prevent wheel spin by providing positive, controlled torque to all wheels. For differential lockout operation, proceed as follows:

a. When traction conditions are favorable, operate the vehicle with the differential lockout control in the OFF position. Do not negotiate sharp corners, travel at high speeds, or operate vehicle any longer than absolutely necessary with differential lockout in the ON position. Operating with differentials locked increases the possibility of axle shaft breakage and differential gear damage.

b. When traction conditions warrant, shift to the ON position to provide positive drive to all wheels. Never place control ON to lock differentials while operating at high speeds, in sharp turns, or if one wheel is spinning or slipping.

c. Place the control in the ON position only when the truck is stopped or moving slowly, and ease up on the throttle to facilitate the shift.

d. You may place the control in the OFF position at any moderate speed under favorable traction conditions.

Shutdown. Bring the vehicle to a stop, place the transmission gear selector in neutral, and apply the parking brake by pulling out on the control knob. Operate the engine at a fast idle (1000 to 1200 RPM) for three to five minutes to stabilize engine temperature.

Reduce engine speed to low idle for 30 seconds. Failure to allow engine to idle for at least 30 seconds before engine shutdown will result in turbocharger damage. Shut off all lights, blowers, and accessory controls. Turn and hold the engine shut-down switch to ENGINE SHUT DOWN position until the engine stops completely. Turn the engine shutdown switch to the OFF position and place the chassis electrical master switch in the OFF position. Check to insure that the short circuit indicator light is OFF. If light is ON, one or more switches are closed (in operating position).

Post Operational Procedures. Immediately upon return from a firefighting mission, service and check the vehicle. Conduct an inspection of the vehicle to determine if any physical damage has occurred to the vehicle or components/accessories during the mission. Flush the foam system as follows:

a. Fill the water tank.

b. Open roof turret discharge valve.

c. Open bumper turret discharge valve.

d. Unreel handline a few feet and open handline discharge valve and nozzle.

e. Open handline compartment drain valve.

f. Open water drain valve and foam drain valves in water pump compartment.

g. Place flushing control valve (5, fig. 4-7) located in the cab, to the ON position.

h. Start engine, and place agent selector control (1, fig. 4-7) at WATER position.

i. Discharge water from lines until system is clear of foam.

j. Shift agent selector from WATER to OFF position.

k. Close flushing valve and all other valves opened in steps b, c, d, e, and f.

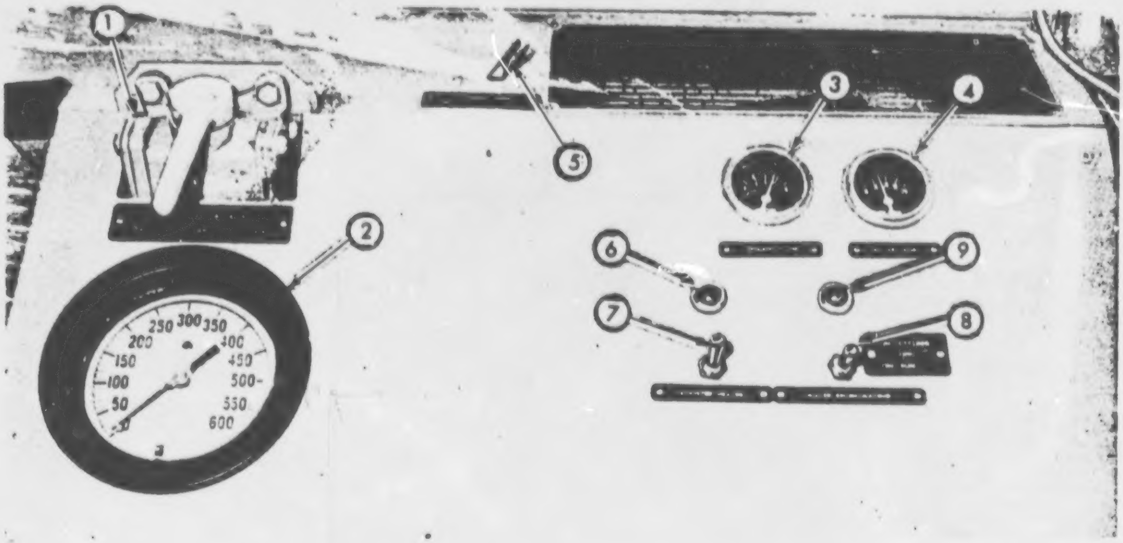
l. Actuate air purge control to blow out handline and nozzle. Reel in handline and stow nozzle in compartment.

m. Perform all pre-operational checks and services.

Exercises (862):

1. Which controls and instruments are grouped within easy reach of the driver's normal seated position?

2. The low air warning buzzer will shut off after engine has started and ______ system air pressure builds up to ______ psi.



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1. Agent selector
2. Pump pressure gage
3. Coolant pump pressure gage
4. Water tank temperature gage
5. Foam system flush control
6. Booster heater warning light
7. Booster heater switch
8. Water recirculating pump switch
9. Recirculating pump cycling indicator

Figure 4-7. Equipment operator's controls and instruments.

3. What should you do if the engine does not fully start within ten seconds?

4. During normal operations, the P-4 engine should be run for how long and at what RPM before applying a load?

5. When should 1st and 2nd gears on the P-4 be used?

6. What will happen if the engine speed is allowed to fall below 1500 RPM between shifts of the P-4 transmission during driving operations?

7. When should you NOT downshift the P-4 to aid in braking?

8. What permits one wheel to turn faster than the opposite wheel when negotiating corners or rough terrain?

9. The differential lock control should NEVER be placed in the on position under what conditions?

10. What should be done to stabilize engine temperatures and prevent turbocharger damage?

11. How long should the engine shut-down switch be held to the engine shut down position?

12. In what position should the agent selector control be for flushing the foam system?

863. Give recommended actions for operation of the P-4 in the crash mode.

General procedures given in the following paragraphs cover only the use of the equipment during firefighting operations, and no attempt is made to instruct personnel as to firefighting techniques in particular situations. The vehicle is designed as a multipurpose vehicle, having primarily two modes of operation: Crash Mode and Structural Mode.

In the Crash Mode of operation, the vehicle will discharge foam concentrate and/or water from storage tanks within the vehicle body, through the roof and bumper turrets and the handline. Each of the discharge turrets is individually controlled by operators inside the cab while the handline is controlled by the handline operator at the nozzle. During this mode of operation, primary control of the pumps and agent system is accomplished from the equipment operator's control panel inside the cab. The vehicle operator may move the vehicle about the site of the fire while discharging through all nozzles.

Crash Mode Operation. Primary control of the firefighting system during crash mode operation is accomplished from the equipment operator's control panel (fig. 4-7). When operating the vehicle in the "Crash" mode, the operator should not shift the main agent selector valve in the cab from the "Water" position to the "OFF" position and back to the "WATER" OR "FOAM" position until the engine has dropped to idle, with the agent selector valve in the "OFF" position. ENGAGING THE AGENT SELECTOR VALVE TO EITHER ITS "FOAM" OR "WATER" POSITION AT ENGINE SPEEDS ABOVE THE IDLE WILL HAVE A DETRIMENTAL EFFECT ON THE LIFE OF THE CLUTCHES, DRIVELINES AN PUMPS.

During normal procedures, pumping will be accomplished with the vehicle stationary or moving slowly. The pumps may be engaged in any gear range at any vehicle speed, by means of the agent selector valve. When the vehicle arrives at the crash site, the transmission may be downshifted and the following procedures observed:

a. Place the agent selector in the desired position — FOAM or WATER. This selection controls the agent to be discharged through the roof turret, bumper turret, and handline. Actuation of this control causes the pumping governor to hold the engine speed at 1800 RPM, and also engages the foam and water pump clutches.

b. Actuation of this control also transfers the throttle pedal control to a modulated clutch control. The modulated clutch is progressively engaged as the pedal is depressed. This will then permit you to move the vehicle in either a forward or reverse direction when maneuvering about the site of a fire and dispensing foam or water through the roof turret, bumper turret, or handline. The normal operation of the vehicle transmission in the crash pumping mode is reverse, neutral, first, or second ranges. This will permit movement of the vehicle at speeds up to 10 mph while pumping. Under no condition, during modulating clutch operations, should the transmission be shifted into reverse, or from reverse to forward gears, without first bringing the truck to a complete stop. In modulating clutch operations, the modulating clutch must be completely disengaged by removing all pressure from the foot pedal before shifting into reverse or from reverse to forward gears. The modulating clutch is operational only when pumping is controlled by the agent selector control in the cab.

c. Check the pump pressure gage (2, fig. 4-7) for proper indication of water pump pressure. Water pump pressure should fall in the range of 225 to 275 psi.

d. Check the roof turret hydraulic system pressure (normally 500 to 600 psi) on the gage in the turret control panel. No hydraulic pressure will be indicated until the turret is unlocked and ready for use.

e. Firefighting system is ready for discharge through either turret or handline.

Roof turret operation. The agent selector (1, fig. 4-7)must be in FOAM or WATER position. If hydraulic (power assisted) operation of the turret is desired, make certain that control knobs on the roof turret control panel are in the HYDRAULIC position.

Rotate the turret lock control to the UNLOCK position. This will close a solenoid valve in the bypass hydraulic circuit and pressurize the turret hydraulic system. Check the pressure reading on the hydraulic pressure gage. This gage should read between 500 and 600 psi.

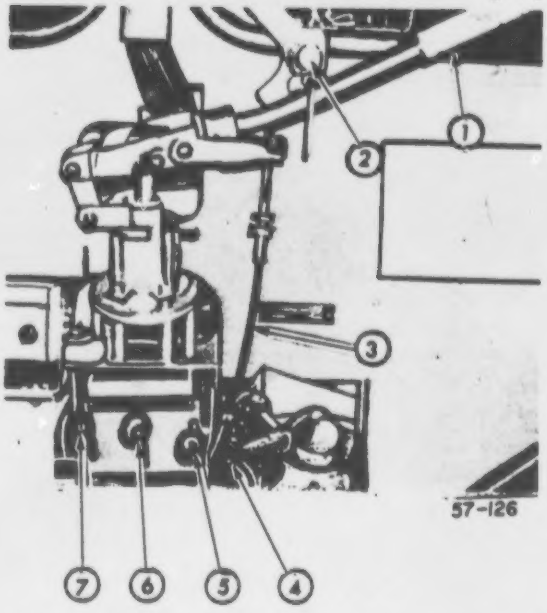
Select the desired discharge rate and water nozzle or foam barrel discharge by placing the selector in one of these positions:

Two Water—800 gpm water discharge
One Water—400 gpm water discharge
One Foam—400 gpm foam discharge
Two Foam—800 gpm foam discharge

The selector lever must be pulled slightly to the right before its position can be changed. This motion actuates a microswitch which will momentarily interrupt turret discharge, thus preventing damage to the selector plate seals when changing flow rates with the turret in operation.

Select the desired pattern by placing the pattern selector lever in any position between DISPERSED (fine, fan shaped spray, 30 feet wide, range of 80 feet) and SOLID STREAM (compact stream — maximum range 160 feet). Aim the turret in direction of desired discharge by means of the turret aiming handle. Place the discharge valve switch in the OPEN position. The turret will then discharge. To interrupt discharge during operation, press the button on the end of the turret handle. Discharge will resume when the button is released. If the electric discharge fails, open the discharge valve manually by rotating the valve control knob to the MANUAL position and placing the lever in the OPEN position. The lever is disengaged in the stored position. To open the discharge valve, pull lever down until the tongue on the lever hub engages the slot in the valve hub: then continue pulling the lever to open the valve. The lever may then be disengaged by pushing it to the left; then return it to the stored position.

If the roof turret hydraulic system fails and manual operation is necessary, rotate the turret control knob to the MANUAL position, and control the turret with the handle just as during normal operation, though omewhat greater effort will be required.



1. Bumper turret handle
2. Handle locking lever
3. Push-pull control lever
4. Discharge valve lever
5. Pattern selector knob
6. Velocity knob
7. Agent selector discharge knob

Figure 4-8. Bumper turret handle

To terminate operation, shut off the discharge valve switch. If the turret discharge is manually operated, push the lever up to the CLOSED position, then disengage the lever from the valve hub and return the lever to the stored position and place the agent selector valve to the OFF position.

Bumper turret operation. All controls for the bumper turret are located at the front center of the inside cab wall. These controls are shown in figure 4-8. Controls are located so that either the vehicle operator or equipment operator may operate this turret. All functions of the turret are manually controlled as follows:

a. Rotate turret handle locking lever (2, fig. 4-8) to disengage turret lock assembly located on front of cab (driver's side).

b. Agent selector valve (1, fig. 4-7) must be in FOAM or WATER position.

c. Aim turret in desired direction by means of handle (1, fig. 4-8). Handle may be held in position by means of position latch (2) which will lock the turret in the storage or groundsweep position.

d. Select desired agent discharge nozzle by pushing knob (7) down for FOAM or pulling up for WATER.

e. Select dispersed or solid stream, using knob (5) which is variable to any position between DISPERSED or SOLID.

Bumper turret range is 125 feet in SOLID pattern, 60 feet in DISPERSED (high velocity), 30 feet in DISPERSED (low velocity).

f. Open discharge valve by pulling back on lever (4). Turret will begin discharging. If it is desired to change agent location (FOAM to WATER, or WATER to FOAM) while discharging, discharge valve lever (4) MUST be closed before changing agent selector valve (1, fig. 4-7) and reopened after agent selector valve is set. Failure to close valve lever during agent selector change-over may result in extremely high surge pressure and ruptured lines.

g. If low velocity application of foam is required for groundsweep, pull upward on velocity knob (6) to partially restrict the flow of foam through the turret.

h. When operation of turret is completed or agent is exhausted, close discharge valve (4) and return turret to stored position.

i. Place agent selector valve in OFF position.

Handline operation. The handline is operated from the front of the vehicle. The handline reel contains 150 feet of hose which may be unreeled as necessary. Rewind of hose is accomplished by means of an air motor, and a manual crank is furnished to be used in case of motor failure. The handline nozzle is stored while attached to the handline so that it is ready for instant use.

Open the handline compartment door at the right front of the truck cab. Open the small lower door and manually pull a few feet of hose from the hose reel. Remove the retaining strap, and remove nozzle from bracket. Open the handline discharge valve. The agent selector valve must be in FOAM or WATER position before handline is operable.

Unreel as much hose as desired, and place the selector in position for WATER (clockwise) or FOAM (counterclockwise). Start the nozzle discharge by depressing the pistol-grip discharge lever; full depression gives full discharge rate. Select the desired pattern by turning the pattern control counterclockwise for a solid stream, clockwise for a dispersed pattern. This regulates the pattern on foam discharge only. For water discharge, the pattern selector on the end of the water nozzle must be adjusted prior to discharging. If bayonet applicator is to be used, remove the bayonet applicator and install it in the socket at the end of the water nozzle. The pattern selector must be removed and the detent held open to allow insertion of bayonet applicator. The selector must be in WATER position when using bayonet applicator.

To terminate operation, release the discharge valve lever and remove the bayonet applicator. Close the handline discharge valve. Open the handline nozzle pistol grip lever to release pressure inside the handline. Hold the handline nozzle lever open and place the handline purge control ON to blow out moisture from handline piping, hose, and nozzle. The handline rewind motor will not actuate unless transmission is in neutral. Engine will accelerate to 2000 RPM when the rewind button is actuated to provide air supply for rewind.

Have a second person depress the rewind button and carry the nozzle back to the vehicle as the hose is rewound. The assistant should guide the hose onto the reel. Leave a few feet of hose unwound, as some slack is required to enable the nozzle to be placed in its compartment. If the powered rewind fails, use the manual rewind crank on the shaft to rewind the hose.

Return the handline nozzle and crank to their storage compartment and secure them. Close and secure the lower door handline compartment door and the nozzle storage compartment door.

Exercises (863):

1. Primary control of the firefighting system during crash mode operation is accomplished from what position?

2. When operating the P-4 in crash mode, how much of a hesitation should be made in the off position of the agent selector valve when shifting from water position to foam position?

3. While in modulation clutch operation, when may the vehicle transmission be shifted into reverse or from reverse to forward gears?

4. When proper water pressure is indicated, the water pump pressure should fall within what range?

5. The agent selector on the P-4 must be in what position for roof turret operation?

6. What happens when the turret lock control is rotated to the unlock position?

7. In what position should the selector be placed for 800 gpm foam discharge from the P-4 roof turret?

8. A compact stream from the roof turret on a P-4 has a maximum range of how many feet?

9. How do you terminate a hydraulic roof turret operation on the P-4?

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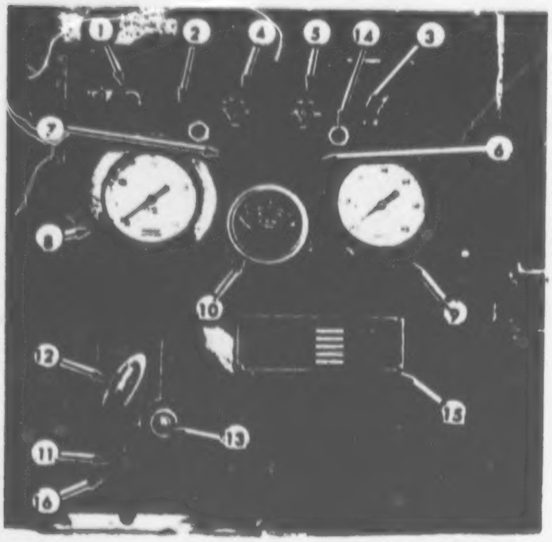
10. What are the ranges of the various patterns for the P-4 bumper turret?

11. How is low velocity foam application achieved when needed for groundsweep?

12. The vehicle transmission must be in what position for the handline rewind motor to actuate; and once it does actuate, to what speed will the engine accelerate?

864. State recommended practices for using the P-4 in situations which require structural and structural mode operations.

Structural Operation. During structural operations, primary control of the firefighting system is accomplished from the structural control panel on the left side (outside) of the truck. This panel is illustrated in figure 4-9. In structural opèration, the system may be operated from inside or outside the vehicle.



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1. Panel light
2. Panel light switch
3. Priming pump switch
4. Oil pressure gage
5. Coolant temperature gage
6. Water pump clutch control
7. Engine throttle control
8. Water pump suction gage
9. Water pump pressure gage
10. Engine tachometer
11. Relief valve control
12. Pilot valve control
13. Strainer access plug
14. Gage check ports
15. Pump delivery plate
16. Valve stop

Figure 4-9. Structural control panel.

When the vehicle is brought to a stop and the gear range selector is placed in "N" (neutral), air pressure is supplied to the structural control panel water pump clutch control (6, fig. 4-9).

Pumping from hydrant supply. In pumping from a hydrant supply, the vehicle may be positioned at the hydrant or at the scene of the fire. When the vehicle is to be *positioned at the fire* for discharge through turrets, handline, and hoses, complete the hydrant connections as follows:

1. With the vehicle positioned near a hydrant, remove enough hose from the hose bed at rear of the vehicle to make connection to the hydrant.
2. Remove the hydrant wrench and coupling (spanner) wrench from the storage compartments on the left side of the vehicle.
3. Signal the vehicle operator that preparations for the hose lay are complete by depressing the hose lay signal button on the side of the engine cover.
4. Connect the hose to the hydrant, using adapters if required, and stand by to open hydrant when required.
5. When the vehicle has reached position for pumper operation, the operator must set parking brake and place the gear selector in "N" (neutral) position.
6. Couple the hydrant hose to the 2½-inch suction inlet on the side of the vehicle and open inlet valve.
7. Close the butterfly valve by pulling the control all the way out.
8. Turn hydrant supply ON.
9. Couple hoses and nozzles, as required, to the 2½-inch discharge valve connections on either side of the vehicle.
10. Vehicle is now ready for structural pumper operation.

When the vehicle is to be *positioned at the hydrant* for pumper operations complete hydrant connections as follows:

1. With the vehicle positioned near the fire, remove enough hose from the hose bed for adequate working line.
2. Remove necessary nozzles and adapters from the storage compartments on left side of vehicle.
3. Signal the vehicle operator that preparations for the hose lay are complete by depressing the hose lay signal button on the side of the engine cover.
4. When the vehicle has reached the hydrant, the operator must set parking brake and place gear selector in N (neutral) position.
5. Break the 2½ hose from the hose bed and couple to any 2½-inch discharge connection.
6. Using additional 2½-inch hose, complete the connection between the hydrant and the 2½-inch suction inlet on either side of the vehicle.
7. Close the butterfly valve by pulling the control all the way out.
8. Turn the hydrant supply ON.
9. Vehicle is now ready for structural pumper operation.

Pumping from draft. In pumping from draft, water is drawn from a supply such as a pond, lake, swimming pool, etc., and proceed as follows:

a. Maneuver the vehicle as close as possible to the water supply. Leave the engine running, transmission in N (neutral). Place the agent recirculating valve, located on the roof turret control panel above the driver, in the closed position.

b. Attach 1, 2, or 3 sections of 5-inch suction hose to suction inlets on either side of the vehicle.

c. Close the water tank butterfly valve by pulling the control all the way out.

d. Attach the suction strainer to the end of the suction hose before immersing the hose in the water supply. In placing the hose, make certain that no part of the hose is higher than the 5-inch suction inlet on the side of the vehicle to avoid the formation of air pocket in hose. When placing the strainer in water supply, make certain that the strainer is far enough above the bottom to avoid drawing in sand, gravel, or other abrasive material. Such foreign material will seriously impair pump performance and shorten service life.

e. Immerse the suction strainer at least two feet below surface of the water supply to prevent the formation of whirlpools which allow the pump to draw air and lose prime.

f. Couple the necessary hoses and nozzles to the 2½-inch discharge connections on each side of the vehicle. Make certain that the discharge valves are closed.

g. Establish water pump prime by depressing the priming pump button (3, fig. 4-9). All discharge ports MUST be closed before attempting to prime the pump. A definite change in the sound of the priming pump will be heard when priming is complete, and water discharge will be seen from the priming pump discharge line underneath the vehicle.

h. Engage water pump clutch control (6) and adjust engine throttle to approximately 1000 RPM by pushing the button in center of the throttle control (7) and pulling out, while observing engine RPM as shown on tachometer (10).

i. Check water pump pressure gage (9) for reading, indicating the pump is primed and developing pressure. Vehicle is now ready for structural pumper operation. If no reading is evidenced on the pressure gage, the water pump has lost prime and will have to be reprimed before continuing with pumper operation as outlined.

Structural Mode Operations. In the structural mode of operation, the vehicle must remain stationary and the primary control of the firefighting system is accomplished from the structural control panel on the left side of the vehicle just behind the cab. In this mode of operation, the vehicle will discharge water from a hydrant supply or from draft supply such as a pond, lake, etc., through the roof or bumper turrets, front handline, or from discharge connections on each side of the vehicle to which may be coupled 500 feet of 2½-inch hose, with variable pattern and shutoff nozzles. In this mode, various interlocks are actuated which prevent the vehicle transmission from being shifted out of the N (neutral) range and which transfer control of engine speed to the hand throttle on the structural side panel. In this mode the firefighting system is operated from outside the vehicle.

a. If not engaged previously, engage water pump clutch by means of control (6, fig. 4-9). Engaging the water pump clutch by means of the structural panel control will engage an interlock system, preventing the transmission from being shifted out of neutral (N). This is for the protection of personnel and equipment deployed around the vehicle during structural operations. Make sure the clutch control is returned to the OUT position when structural operations are complete.

b. Turn the relief valve control (11) to the ON position.

c. Adjust the engine throttle speed for desired output pressure. Refer to the data plate on the structural control panel for proper speed settings. Push the bottom in the center of the throttle control (7) and pull out to increase engine speed. Fine adjustments of the engine speed are made by turning the throttle knob.

d. Check the pump pressure gage (9). If the reading is not at the pressure desired, turn the pilot valve control (12) clockwise to increase pressure or counterclockwise to decrease pressure as required.

e. If the discharge pressure is desired to be controlled by engine speed, turn the relief valve control to OFF. This will prevent the relief valve from unseating by bypassing the pilot valve.

f. Open the desired 2½-inch discharge valves by pulling up on their control levers.

g. The roof turret, bumper turret, and handline may be operated as deluge guns. However, the roof turret hydraulic system is by-passed during structural operations to prevent fluid overheating. Therefore the roof turret can only be operated manually.

Nurse Truck or Relay Operation. Whenever the vehicle must operate at extended distances from the water supply, or very high discharge pressures are required to pump water to great heights, the vehicle may be coupled to a nurse truck or a second pumper in relay. The discharge from the nurse truck or relaying pumper should be connected to either of the 2½-inch suction inlets at the side of the pumper vehicle. If you wish to control discharge pressure by engine speed, turn the relief valve control to OFF. Do not attempt to discharge more water than is available from the hydrant, draft, or relaying pumper. Monitor readings of the suction compound gage (8, fig. 4-9). A falling reading indicates that water is being discharged faster than it is being supplied to the pump. Lower the pump speed or shut off one or two nozzles to lower the discharge rate to prevent loss of prime.

Exercises (864):

1. When the P-4 is operated in the structural mode, water may be discharged through which of the discharge outlets/openings?

2. Where is primary control of the firefighting system accomplished on the P-4 during structural operations?

3. When pumping from a hydrant supply, where is the P-4 positioned?

4. How is the vehicle operator notified that preparations for the hose lay have been completed?

5. When priming the pump during drafting operations with the P-4, how can you tell when the priming is complete?

6. During a drafting operation, the engine of the P-4 should be throttled to approximately what RPM after the water pump is engaged?

7. What provisions are made for the protection of personnel and equipment around the P-4 when it is operated in the structural mode with engagement of the water pump by means of the structural panel control?

8. What should you use for proper engine speed settings for structural mode operation?

9. If the discharge pressure is to be controlled by engine speed, in what position should the relief valve be set?

10. What must be done to use the roof turret as a deluge gun from the P-4?

11. Which suction inlet(s) should be used when pumping from a nurse truck?

12. What is indicated and what action should be taken if a fall in discharge pressure is noted during a pumping operation from relay?

865. Give recommended procedures for reservicing the P-4.

Draining Foam Tank. Before draining the foam tank, you should obtain suitable containers for storage of the foam concentrate. This concentrate is very expensive and every attempt should be made to salvage as much of the liquid as possible.

Locate the foam tank drain valve. The valve is accessible from inside the small body compartment located directly over the left rear wheel well. Next, locate the lower end of the foam tank drain line connected to this valve and place the clean container under the end of the hose.

Open the foam tank drain valve and allow concentrate to drain until the tank is empty; then shut off drain valve. Once the foam tank has been drained, it is advisable to flush the piping system, to remove all traces of the foam concentrate, which is very corrosive.

Draining Water Tank and Piping. Locate the main water tank drain valve. This valve is located over the forward rear axle, and is accessible from the left side wheel well. Open the main water tank drain valve by pulling on the valve handle, and allow the tank to drain thoroughly.

Remove the caps from the 2½-inch and 5-inch suction inlet connections on each side of the vehicle. Open valves by pulling knob out. Remove the caps from the 2½-inch discharge connections on each side of the vehicle, open the valves by pulling the lever out and upward. Remove the cap from the 2½-inch pressure inlet at the rear of the vehicle on the left side. Assure that the dispensing handline discharge valve is in closed position.

Open the handline and purge the handline system by actuating the purge valve on the front of the vehicle, just to the right of the handline compartment.

In addition to the above procedures, the manifold drain valves at the low points in the lines to the roof turret, bumper turret, and handline must be opened to drain the system completely. These valves are located in the nozzle compartment and the water pump compartment. After drainage of the system is complete, close all valves and install and tighten all piping caps.

Filling Water Tank From Overhead. Before filling the water tank from overhead, make certain that the strainer basket is in place and insure that the basket is clean.

Open the filler cover and insert a filler hose end into the strainer basket. Open the supply valve and fill the water tank.

Filling Water Tank From Hydrant. Filling from a hydrant requires the use of a 2½-inch hose and suitable couplings such as those furnished in the KMK-391/S32P-4 Structural Fire Fighting Kit.

The water tank filler cover should be opened and the strainer basket removed when filling from a pressure source to prevent damage to the water tank and provide positive air escape during filling.

Connect a 2½-inch hose to the pressure fill inlet at the rear of the vehicle, connect the hose to a hydrant outlet, and using a hydrant wrench, open the hydrant supply. Shut off the hydrant supply when the tank is filled and disconnect the hose from the hydrant. Drain the hose and roll for storage. Install the cap on the pressure fill inlet line. Some water spillage will occur when the hose is disconnected as the water in the fill line drains out.

Filling Foam Tank From Overhead. The foam tank filler box contains a strainer screen and incorporates four can piercing knives to expedite the filling procedure.

Open the foam tank filler box cover. If standard 5-gallon cans of concentrate are being used to fill the tank, use a sharp downward motion to set the cans in place over the piercing knives. This action pierces the can so that it will drain completely in 20 seconds or less. Provision is made for the draining of four cans simultaneously.

If a transfer hose is being used to fill the tank, place the hose in the filler box trough and proceed to fill the tank at the desired rate, up to 75 gpm.

After filling the tank, close the filler box cover and secure both latches.

Filling Foam Tank From Bulk Supply. The foam tank may be filled from a 55-gallon drum or other bulk supply, provided that a manual or other type transfer pump is used in the fill line.

Locate the remote foam tank filler connection at the rear of the vehicle. Remove the cap from this connection and connect a 1½-inch hose. Connect this hose to a transfer pump on the bulk supply. Operate the transfer pump until the level, which can be observed by a helper on top of the vehicle, indicates that the tank has been filled. Disconnect the hose from the filler connection and retrieve spillage from the filler pipe by placing a clean container under the exposed end of the pipe. Install and tighten the pipe cap and close the filler box lid.

Exercises (865):

1. Why should every attempt be made to salvage as much of the foam concentrate liquid as possible when draining the P-4 foam tank?
2. The foam tank drain valve is accessible from which compartment?
3. Once the foam tank has been drained, what action should be taken and for what reason?
4. Where are the turret and handline manifold drain valves located?
5. How may the water tank on the P-4 be filled?
6. When a transfer hose is used to fill the P-4 foam tank from overhead, the tank may be filled at a rate of up to how many gpm?
7. What size hose is used to fill the P-4 foam tank through the pressure fill at the rear of the truck?

CHAPTER 5

Support Vehicles

NORMALLY, each of the vehicles assigned to a fire department can be placed in one of three categories; (1) structural pumpers, (2) aerospace firefighting vehicles, and (3) support vehicles. It is important that personnel assigned to the fire department know the general design, capabilities, operating procedures, and tactical uses of all assigned vehicles.

Vehicles designed for fire protection started taking on a new look in the early 1950's to keep up with the new concepts, capabilities, and designs of aerospace vehicles. Unfortunately, support vehicles did not keep pace with the updating process. Vehicles designed for use in 1942 were still in use as support vehicles in the early 1960's. Even now there are far too many of the older vehicles still in use, but the picture is not completely bad. Much progress in research and development is taking place in the area of support vehicles. Some of the new changes are already in the field. One change, for instance, is that some support vehicles are selected from commercial designs. Now, the selection of a vehicle to do a particular job can be much closer to the original requirements than ever before. Another development is the use of large capacity specialized units to bolster the fire department runway foaming capabilities. Many more improvements have been made but are too numerous to mention here.

Two more or less recent changes in the field of support vehicles are the additions of the ½-ton pickups and the water distributors. These vehicles provide support for all phases of fire protection. An outline of the requirements for each vehicle and a list of equipment most likely carried on them will be provided in this chapter. The ½-ton pickups will be referred to from here on simply as "pick-ups," and the water distributors will be called by their more common name of "tanker." The first portion of this chapter will deal with pickups and the last portion will deal with tankers.

5-1. Pickup Trucks

Each fire department which has a fire chief, an assistant fire chief, and a technical services section will be assigned three ½-ton pickups. These pickups are assigned in accordance with the Table of Allowances 010. Additional pickups may be assigned to fire departments as they are needed. TA 010 specifically states that each fire chief and assistant fire chief on duty will be assigned a vehicle in accordance with his position. The third pickup is assigned to the fire department for use in the maintenance of fire extinguishers, fire protection systems, and fire inspection duties. The technical services section of the fire department is responsible for the duties just mentioned above.

These pickups are commercial in design and may be manufactured by Chevrolet, Dodge, Ford, etc. Of the three assigned to any particular base, each may be manufactured by a different company. Consequently, it is not practical or necessary to describe how each type may operate. It will be enough to say that these pickups are standard equipped and may have automatic or manual transmissions. Some ½-ton pickups may be equipped to provide a front-axle drive which greatly adds to its uses. A transfer case lever in the cab is shifted to engage a drive shaft from the transfer case to the front axle. Then the driver must turn a dial assembly mounted on the hub of each front wheel. The turning of this dial either unlocks or locks a spline to the axle drive. When the front drive is no longer needed, the dial on each hub is returned to the unlocked position and the transfer case shift lever in the cab is placed in neutral. This added feature built into some pickups provides for the 4x4 drive needed to accomplish many tasks. Remember, 4x4 means that four wheels are on the ground and all four capable of being powered. These pickups are the same vehicles which you could purchase at any car sales outlet. Once assigned to the fire department, they will be equipped with the specialized items needed to perform their assigned tasks. Each of the three pickups may be equipped identically or individually to perform a particular job. The pickup should be equipped to function in as many different situations as possible Each base will equip its pickups to fit the particular needs of that base.

The operation of each pickup will depend upon the manufacturer's design. The good driving habits you studied in Chapter 1 of this volume should be used to assure safe operating conditions. In order for you to be knowledgeable of the use and possible variations of equipment carried on these pickups, an example description of each follows: Remember, a complete list of all equipment which may be carried is not possible, but a generalized list will give you an excellent knowledge of what to expect.

866. State uses of and list equipment on the pickup trucks assigned to the fire department.

Base Fire Chief's Pickup. This vehicle will be equipped with a two-way fixed radio communication system. This system may be made up of one or two separate radios capable of contact with the base commander, the base fire marshal, base operations, the control tower, the hospital and ambulances, security headquarters and patrols, utility vehicles, all firefighting vehicles, and inflight aircraft. In addition, a portable two-way radio will be carried for the use of the fire chief while outside the vehicle. The pickup will be equipped with emergency lighting and sounding devices equal to standard firefighting vehicles.

Some items of equipment carried will be an accurate timing device for determining the time which the weapons are envolved with fire, a bull horn, protective clothing and breathing apparatus, maps of the base and surrounding off-base areas, a clipboard with writing material, and portable lights. A master stream nozzle may be mounted in the bed for use while on the pickup or portably carried for use wherever desired. A toolbox is usually manufactured locally and mounted in the bed to carry various tools and the chief's protective clothing and breathing apparatus. The equipment mentioned may not be a complete list of what you may have on a given pickup, but it is a fairly representative coverage.

The fire chief's vehicle should be used just as the name implies. That is, for transportation of the fire chief only. Unauthorized use on this pickup could leave the chief stranded. The chief must be able to respond immediately to any given situation to be "on top" of the situation from the beginning. Any delay of the chief's arrival could have serious effects on the successful completion of an operation.

Many times throughout a day, the fire chief's vehicle will be used for administrative runs to and from different offices on or off the base. Visits will be made by the fire chief to each of the fire stations, usually on a daily basis. Other calls for the fire chief to attend a conference with the base commander or to meet with the base fire marshal will add extra miles to this pickup. All in all, the fire chief's vehicle is usually very busy. It is important to remember that the fire chief's pickup is a mobile command post from which the fire chief is capable of sustaining the operations of the fire department and other support agencies.

Assistant Fire Chief's Pickup. The duties of the assistant chief for operations require that they must also be mobile at all times. The assistant chief is directly responsible to the fire chief for all activities concerning the operations section within the fire department. In the absence of the fire chief, the assistant chief assumes the fire chief's duties, plus his own. You can understand his need for transportation. The assistant chief does not use the fire chief's pickup during the fire chief's absence, since the fire chief's pickup must be available for the fire chief to use at all times. With this in mind, you can also understand why the assistant chief's pickup should be equipped with the same items as the fire chief's.

During a tour of duty, the assistant chief must visit each of the fire stations at least once a day. Many times the assistant chief will make repeated visits to one or all of the fire stations, which can be separated by many miles. In fact, the assistant chief is, in a sense, a roving fire chief. He makes sure that everything is operating smoothly in all areas of the fire department except the technical services and administrative areas. Usually, many more miles are traveled by this pickup than any other vehicle except the pickup assigned to the technical services section and the ramp patrol vehicle.

Technical Services Pickup. The pickup assigned to the technical services section of the fire department has many and varied uses. This pickup is usually not as fully equipped as the pickups belonging to the fire chief and the assistant chief. Other than having a fixed two-way radio communication capability, a portable two-way radio, and emergency lighting and warning devices, the vehicle is standard equipped. This pickup is used as the workhorse of the fire department. Many are equipped to do specialized jobs as situations may require. For instance, some are equipped with a hoisting device for loading and unloading heavy fire extinguishers. Others are equipped with extinguishing agents to assist in the standby requirements of minor fire hazards. Others may have a toolbox containing a variety of tools not normally carried on firefighting vehicles. Almost all of them are equipped with a hitch for pulling trailers or wagons. Some may also be equipped with master-stream nozzles, especially at bases which have buildings more than two stories high and which cover thousands of square feet.

A normal day in the life of a technical services pickup will usually include carrying the fire inspectors to and from their assigned areas of inspection, picking up and delivering fire extinguishers, picking up the meal rations from the mess hall and delivering them to each fire station, picking up and delivering supplies and personnel to each fire station, and as many other errands as you can think of that an organization working 24 hours around the clock may have need of. Remember though, this pickup is primarily assigned to the technical services section to mobilize their inspection teams and to assist in the maintenance of fire extinguishers. During emergency situations this pickup may be used to move personnel, carry supplies of foam and other extinguishing agents, be connected into a structural hose layout for use of the master-stream nozzle, or used as a fire department guard post at the scene of a structural fire or aerospace vehicle crash. The uses and the equipment mentioned in connection with the technical services pickup by no means complete the particular needs of every base.

Exercises (866):

1. What type of communications equipment is normally installed in the fire chief's vehicle?

2. Why is a fire chief authorized a vehicle for his own official use?

3. The chief's vehicle should be able to function as a mobile command post for what type of firefighting operations?

4. Why doesn't the assistant chief use the chief's vehicle?

5. Why should the assistant chief's vehicle have the same equipment on it as the chief's vehicle?

6. What equipment does the technical services vehicle have in common with the chief's vehicle?

7. At bases where there are heavy extinguishers to be lifted, what provisions may be made on the technical services vehicle for this task?

8. What is the primary purpose for having a vehicle assigned to technical services?

5-2. Tankers

According to the present allowances authorized by TA 010, tankers are assigned to fire departments in accordance with the fuel capacities of aircraft using the air bases. An example of this would be an air base which has aircraft with fuel capacities of less than 3600 gallons. Such a base would be allowed one tanker. Another base which has aircraft with fuel capacities in excess of 16,000 gallons would be allowed two tankers.

At the present time, the tanker authorized for use in the fire department carries 1500 gallons of water. If this tanker is not available, a substitute vehicle is authorized according to TA 010. The substitute is a semi-trailer unit which can carry 2500 to 5000 gallons of water. Some bases are still using the old, and now obsolete, 1000-gallon tanker until the 1500-gallon tanker or semi-trailer tanker is made available to them.

Tankers are assigned the same basic tasks regardless of their capacity or location of assignment. Some of these tasks include the washdown of fuel spills, foaming of runways, supplying water to structural and aerospace firefighting units, and combating natural cover fires. The list of tasks that have been accomplished by the tankers is a long one, but these represent the more common ones. Each fire department will assign the specific tasks that the tankers are expected to accomplish, and, of course, these tasks will vary from base to base.

867. Give basic construction characteristics of the 1000-gallon tanker.

The 1000-Gallon Tanker. The 1000-gallon tanker body is mounted on a 6x6 ordnance type chassis. You can see in figure 5-1 that the chassis is rugged and specifically designed for use in field and combat areas as well as on improved surfaces. Mounted on the chassis starting from front to rear is a six-cylinder in-line gasoline or diesel fuel engine, sometimes called the prime mover. The engine is capable of producing 196 brake horsepower at 2800 revolutions per minute.

Just behind the engine is the transmission, which has five gears, or speeds, forward. This grouping of gears, called high range, is used to move the vehicle over normal surfaces under normal conditions. When more power is needed than provided for in high range, a transfer case can be shifted to low range. The transfer case is located just behind the transmission, and the lever used to shift it is located on the cab floor to the right of the driver. Usually, low range is used whenever the vehicle is to be driven over rough terrain, up steep inclines, through mud and snow, or over ice. Shifting the transfer case to low range increases the gear ratio within the transfer case, thus allowing the engine to speed up and deliver more power to the wheels. CAUTION: low speeds only should be used while the transfer case is in low range. When traveling over rough terrain, up steep inclines, through mud or snow, or over ice, the intermediate or rear wheels may slip, thus causing the loss of traction. In any such case where the slippage of the intermediate or rear wheels is 8 percent or more, a sprag unit will automatically engage the front wheels. This will happen whether the travel of the vehicle is forward or reverse. CAUTION: Never allow the vehicle to roll backward while in a forward gear or roll forward while in a reverse gear. If you do, "windup" in the power train will prevent the sprag unit from shifting to the forward or reverse underrunning position. Serious injury to personnel or damage to the vehicle may result if these instructions concerning "windup" are not observed.

The cab is mounted above the transmission and transfer case and is designed to carry two people. It has the standard controls such as emergency brake, gearshift, light switches, windshield wiper switch, transfer case shift lever, gage, and heater. Also, normally mounted on the dash, is a fixed two-way radio communication system. Next to the step of the cab on either side of the vehicle is a 12-volt battery and a 55-gallon fuel tank. The two batteries are connected in series to provide a 24-volt system throughout the vehicle. The large fuel capacity (110 gallons) allows for a prolonged operation of the vehicle.

A 1000-gallon cylindrical tank is mounted on a platform directly behind the cab. The water in this

WATER DISTRIBUTOR

(TANK-TYPE, 1000-GAL)

MODEL 73

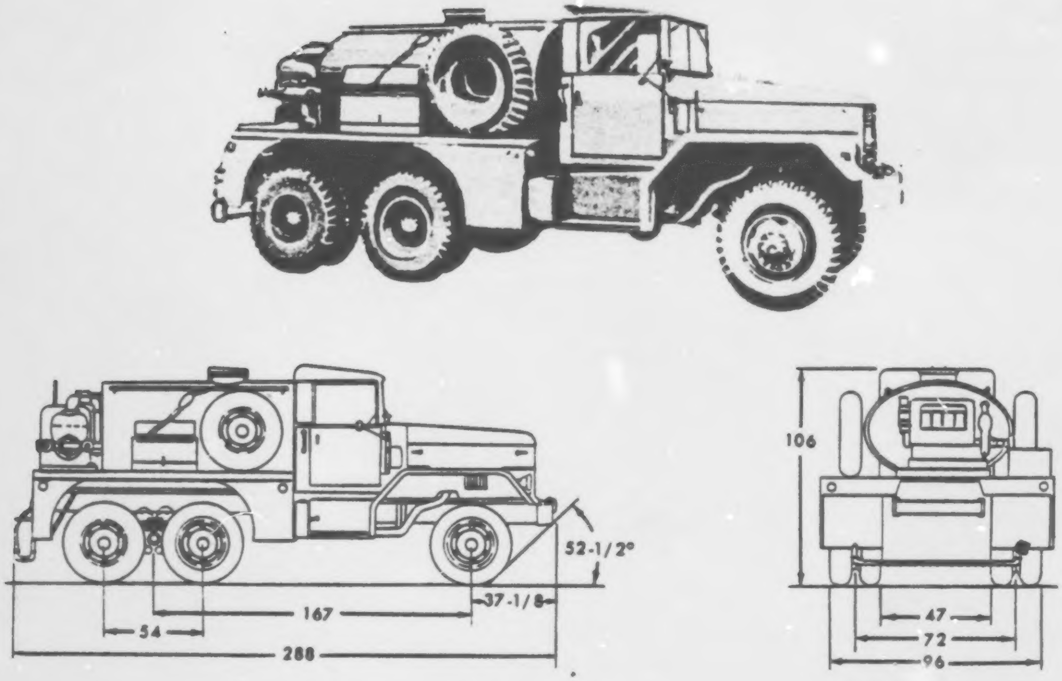


Figure 5-1. 1000-gallon tanker.

tank is gravity fed into a centrifugal pump mounted just behind the water tank. Most models have been modified to include a 100-gallon foam tank, which is usually mounted above the front end of the water tank. The foam tank is used to carry mechanical foam, which is gravity fed into a foam metering device and then into the intake side of the water pump. The water pump is designed to deliver 500 gallons per minute and is driven by a gasoline powered engine. The gasoline engine is commonly referred to as the pump engine. Some of these pump engines come equipped with an electric starter. The others must be started with a handcrank.

Water or water-foam may be delivered from the 500-gpm pump to supply different size hose streams. In some cases, 8- to 24-foot spreader bars are mounted to the rear deck. The spreader bars are connected to the water pump discharge piping so that either a water-foam solution can be sprayed on the ground in 8- to 24-foot swatches or a water application can be selected. A later modification uses standard firefighting foam nozzles attached below the rear deck instead of the spreader bar. The nozzles are positioned at the best possible angle to properly apply the foam-water solution to the ground or paved surface.

Equipment may be mounted on the running boards on either side of the 1000-gallon tank. Some of the equipment may include 5-gallon backpack water extinguishers, axes, rakes, brooms, etc., for combating natural cover fires. The list of tools mounted on the running boards may include those used to accomplish other assigned tasks.

At this point it is necessary to mention some safety precautions involving the operation of this vehicle. The gross weight of this tanker is 29,000 pounds, which is quite heavy for a vehicle its size. The high gross weight of the tanker should be taken into consideration when bringing it to a stop, before crossing bridges, and when driving over unimproved surfaces. The ground clearance between the bottom of the vehicle and the ground is 13 inches. The ground clearance should be a prime consideration when you are driving over rough terrain. Also, a portion of the vehicle weight is concentrated in the water and foam tanks which are mounted high on the vehicle. This top-heavy condition should influence your driving when rounding corners or traveling on the side of a hill. The handcrank for the engine mounted on the rear deck should be used only by personnel thoroughly instructed in its use and fully aware of the safety precautions concerning it. Remember, keep in mind all the facts presented so far to assure the safe and satisfactory completion of any task assigned to the 1000-gallon tanker and crew.

Exercises (867):

1. How many forward gears does the transmission on the 1000-gallon tanker have?

2. When is low range usually used on the 1000-gallon tanker?

3. How wide a foam path can the 1000-gallon tanker lay?

4. What is the gross weight of the 1000-gallon tanker and of what use is this information?

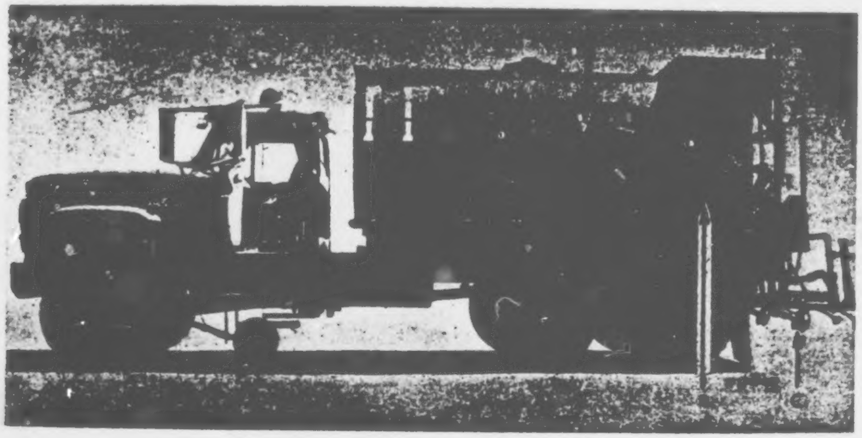
5. How much clearance is there between the bottom of of the 1000-gallon tanker and the ground?

868. State construction characteristics and list tasks of the 1500-gallon and semi-trailer tankers.

1500-Gallon Tanker. Basically, the 1500-gallon tanker is designed along lines similar to the 1000-gallon tanker, and, in most cases, the tasks will be the same as those assigned to the 1000-gallon tanker. The main differences between the two vehicles besides the obvious increase in size to a 1500-gallon water tank (fig. 5-2 item A) capacity is that the tanker chasis and body are commercial in design and construction. The modifications of the 1000-gallon tanker, such as foam tank, electric starter for pump engine (B, fig. 5-2), hose reel, standard firefighting nozzles on the spray bar (C, fig. 5-2) for foaming the runways, and storage compartments for tools and appliances, are features designed into the standard construction of the 1500-gallon tanker.

Semi-Trailer Tankers. As the size and fuel load of our aircraft increased, so did the need for larger capacity water tankers for fire protection activities. Other organizations on base also needed newer vehicles at about the same time; therefore, to save time and money as older semi-trailer tankers from units such as the refueling section were turned in to supply, they were made available to fire protection for modification into firefighting support vehicles. The most popular refueling units made available to fire protection were the F-6 (5000-gallon capacity) and F-7 (2500-gallon capacity). Surplus F-6s and F-7s were removed from fuel servicing duties and fitted with a conversion kit designed to change the use of the F-6 and F-7 from handling aviation fuel to dispensing, storing, and hauling water and foam.

Once the vehicle is converted to a fire department support vehicle, it is assigned designated tasks. Usually, the two primary tasks involve the foaming of runways and handling of fuel spills. Handling of fuel



A. Water tank
B. Pump engine
C. Spray bar
Figure 5-2. 1500-gallon tanker.

spills is normally accomplished by covering the spill with a layer of foam (if the spill is large) or washing the spilled fuel to a safer area and allowing the fuel to evaporate (if the spill is small). Another task in which the semi-trailer tanker, figure 5-3, may assist is decontamination work. In the event of an attack by forces using nuclear, biological, or chemical agents, a vehicle with a large capacity of water will be needed to wash down equipment and personnel. This task may also be assigned to other types of tankers or firefighting apparatus.

The vehicles treated in this chapter perform many different tasks in support of the fire protection mission. On some bases, these same vehicles will be called on to support other base functions as well. Some of the vehicles have no direct firefighting support duties, as you have probably noted. However, the care, maintenance, inspection, and ability to operate them skillfully is as important from the standpoints of safety, reliability, and service as any other vehicle assigned to your fire department.

Exercises (868):

1. The 1500-gallon tanker chassis and body are of what design and construction?

2. Prior to modification for fire protection use, the semi-trailer tankers were used for what purpose?

3. What are the two primary tasks assigned the F-6 and F-7 tankers?

Figure 5-3. Semi-trailer tanker.

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NOTE: Page Number 561 has been omitted.
However, all course material is included.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:
800 - 1. The employment or authorization of employment of such Government vehicles, loaned, leased, or rented for the discharge or performance of an official duty, function, or service.
800 - 2. Physical, mental, and emotional stability.
800 - 3. Check the vehicle technical order or manufacturer's instructions before attempting to operate.
800 - 4. That the parking brake is set and the transmission is in neutral or park position.
800 - 5. All the way out.
800 - 6. At least 30 seconds
800 - 7. The lack of lubrication may cause serious damage to the pistons, bearings and cylinder walls. Racing the engine also wastes fuel.
800 - 8. It causes carbon formation and oil dilution.

801 - 1. In neutral.
801 - 2. 15 miles per hour.
801 - 3. Fully down.
801 - 4. Low
801 - 5. Low
801 - 6. Engine compression.
801 - 7. 20 miles per hour.

802 - 1. You should sit in an erect, comfortable position with your shoulders parallel with the back of the driver's seat.
802 - 2. At the "10 and 2" or "10 and 4" clock positions.
802 - 3. When signaling, adjusting controls, or performing other acts of driving.
802 - 4. No. By releasing the brake slowly, you can start without danger of rolling back.
802 - 5. Second or high gear.
802 - 6. Hand-over-hand method.

803 - 1. When an emergency (or sudden) stop HAS to be made.
803 - 2. By staying alert.
803 - 3. The foot should be removed from the accelerator. If the vehicle has a manual transmission depress the clutch first.
803 - 4. Just before the wheels lock.

804 - 1. Speed.
804 - 2. (1) Each added mile per hour reduces the driver's ability to make the vehicle do what he wants it to do. (2) Each added mile per hour increases the likelihood that an accident will result in death or serious injury.
804 - 3. The speed of the vehicle and the driver's reaction time.
804 - 4. The risk of turning over.

805 - 1. The clutch.
805 - 2. If the road is wide enough and you have a good view in both directions.
805 - 3. A side road turn.

806 - 1. To select a large enough space.
806 - 2. You are likely to side swipe the other vehicle(s).
806 - 3. Be sure that you don't park (1) within an intersection or in front of a driveway; (2) within 25 feet of the curb line of an intersecting street, or within 15 feet of the crosswalk at an intersection where there is no curb; (3) on a crosswalk, sidewalk, or bridge; (4) within 15 feet of a fire hydrant or entrance to a fire station; (5) on a paved or main traveled portion of a rural highway when it is possible to park in the shoulder; (6) unless you can leave at least 15 feet of the road clear for the passage of other vehicles and unless your vehicle can be seen for a distance of at least 200 feet from both directions; (7) on the roadway side of another vehicle (double parking); and (8) where "No Parking" signs have been erected.

807 - 1. The type of district, weather, light, sight distance, speed of other traffic, type of road surface, condition of your vehicle, and your own physical condition.
807 - 2. 20 per cent (or one-fifth).
807 - 3. Yes, when one drives so slowly that he prevents others from driving at a reasonable speed.
807 - 4. In areas where passing is difficult at best and just after cresting a hill or rounding a curve.

807 - 5. This practice confuses and endangers other drivers.

808 - 1. Driving on the wrong side of the road.
808 - 2. Speed and failure to concentrate on driving.
808 - 3. Force.
808 - 4. Friction between the road and the tires.
808 - 5. A skid.
808 - 6. You should expect the curve to be sharp.

809 - 1. Scanning the road in front of you.
809 - 2. Everything.
809 - 3. Warn them of your intentions.
809 - 4. You should notify your supervisor, at once.
809 - 5. Alcohol impairs your driving ability.

810 - 1. It accounts for most of the rear-end collisions.
810 - 2. 120 feet.
810 - 3. By increasing your following distance or lowering your headlight beams.

811 - 1. When NOT to pass and HOW to pass.
811 - 2. You will be exceeding the speed limit to do so and it will take a half mile to complete a pass at these speeds.
811 - 3. (1) On any curve or hill where you cannot see at least 500 feet ahead; (2) At intersections and railway crossings; (3) Whenever there is a solid yellow line in your lane, or a single solid line between lanes; (4) At crosswalks where a car has stopped to allow a pedestrian to cross; and (5) Wherever you cannot see that the road is free of traffic far enough ahead to pass safely.
811 - 4. From 50 to 55 miles per hour.

812 - 1. (a) on highways having at least two lanes going each direction; (b) on one-way streets; (c) when moving past a vehicle which is in a left turn lane; (d) when driving in a "right turn only" lane.
812 - 2. The center lane.
812 - 3. It is safe to return to the right side of the road when you can see the vehicle you have just passed in your rearview mirror.
812 - 4. One, as a general rule.

813 - 1. Help the other driver get past.
813 - 2. Increase your speed.
813 - 3. When the other driver is trying to get back into line behind you.

814 - 1. Drive to the right-hand curb or edge of the road and come to a full stop.
814 - 2. NO.
814 - 3. Firefighter or a police officer.

815 - 1. Walk back along the road to a position where you can signal oncoming drivers to stop in time.
815 - 2. You should contact your supervisor, dispatcher, or service station maintenance crew.

816 - 1. Maintain directional stability of your vehicle and steer to the side of the road/street as soon as it is safe. DON'T jam on the brakes.
816 - 2. In the direction of the skid.
816 - 3. By driving slowly enough for conditions.

817 - 1. Steer straight ahead; as soon as you have slowed enough to have the vehicle under control, steer to the left enough to ride over pavement and not skin the tire sidewalls, and drive back on to the pavement.
817 - 2. (1) Pull on the handbrake; (2) shift into a lower gear; (3) let the clutch pedal out; and (4) turn off the ignition.
817 - 3. Drive at a slow speed with just enough pressure on the brakes to cause a slight drag.

818 - 1. When an accident cannot be avoided, you take action which will result in the lesser amount danger.
818 - 2. To prevent a more serious accident.

819 - 1. 50 feet.
819 - 2. Use only approved cleaning materials.
819 - 3. Not as long as it is carrying dangerous materials.
819 - 4. They will be marked with warning placards.
819 - 5. The vehicle operator.

820 - 1. At the base of the flame.
820 - 2. Most of them (the fires) involve gasoline, oil, and/or electricity.
820 - 3. Your back.
820 - 4. Fires in an enclosed semitrailer can only smolder due to a lack of oxygen.
820 - 5. When the fire has been completely extinguished and the tire has cooled to normal temperatures.

821 - 1. Carelessness, haste, and disregard of existing safety standards by vehicle operators.
821 - 2. Only those designated by the base commander.
821 - 3. Their operator's permit will be overstamped.

822 - 1. To prevent accidental damage to aircraft and possible injury to both flight and ground personnel.
822 - 2. Driver's side.
822 - 3. 25 feet.
822 - 4. 100 feet.
822 - 5. 15 MPH for general-purpose vehicles, 10 MPH for special-purpose vehicles and 5 MPH for all vehicles when in close proximity to aircraft.

822 - 6. The headlights should be turned off (but don't forget to leave the parking/marker lights on).

823 - 1. Clear-to-cross.
823 - 2. General warning. Exercise extreme caution.
823 - 3. Stop and follow-me.
823 - 4. Tugs.

824 - 1. LOW.
824 - 2. A 90-degree angle.

825 - 1. There isn't much room to maneuver the vehicle and the vehicle chassis/components may be damaged from stumps, etc.
825 - 2. Use an established trail if possible; if not, stay as close to an outside edge as possible.
825 - 3. To prevent breaking the sidewalls of the tires.

826 - 1. The lowest speed at which you can maintain traction.
826 - 2. It will only dig in.
826 - 3. Find another crossing point.

827 - 1, To maintain movement with the least amount of strain on the vehicle, its engine, and power train.
827 - 2. Reduce tire pressure.
827 - 3. The windward.
827 - 4. Allow the vehicle to roll to a halt or brake gradually, and if possible on a downhill slope.

828 - 1. Carbon monoxide is poisonous and inhaling the exhaust fumes of a vehicle usually results in death. Remember, "CAUTION: Breathing carbon monoxide may be hazardous to your HEALTH."
828 - 2. Sand, cinders or dirt.
828 - 3. All driven or powered wheels, and non-powered wheels under severe conditions.

CHAPTER 2

829 - 1. While the vehicle is undergoing maintenance.
829 - 2. The operator performing the first daily inspection.
829 - 3. TO 00-20B-5, Vehicle and Base Support Equipment Inspection and Records Administration.
829 - 4. AFTO Form 374.
829 - 5. The P-2/4, O-11A/B, R2-R2A, P-10 Firefighting Vehicles.
829 - 6. Yes, you are using the correct form.

830 - 1. Fuel, oil, water, drive belts.
830 - 2. Replace or repair them.
830 - 3. Full clockwise.
830 - 4. Ease of operation.
830 - 5. 1.225.
830 - 6. Accurate air pressure gage.

831 - 1. Before, during, after. The before-operation inspection makes sure the vehicle is ready for operation before an emergency need arises. During-operation inspection involves reading the engine operating instruments and discovering malfunctions which must be corrected at first opportunity.
After-operation inspections make sure the vehicle will be ready for use when it is needed again.

832 - 1. The date should be entered as month and year. Months with more than five letters should be abbreviated.
832 - 2. A/S32P-8 or P-8.
832 - 3. Use the item serial number or local work order identifier.
832 - 4. When those items are totally inapplicable to the perculiar item of equipment.
832 - 5. By making the correct entry in the operator's signature section opposite the day of the month.
832 - 6. When the particular vehicle concerned is determined not to be required a spark check.
832 - 7. Jamie E. Sommers.

833 - 1. C/F (carried forward).
833 - 2. None.
833 - 3. 0815
833 - 4. The vehicle Ser-O-Plate (AF Form 1252).
833 - 5. When items are to be carried forward to a form for the next month.

CHAPTER 3

834 - 1. 700 (70% of 1000 gpm = 700 gpm).
834 - 2. 250 (50% at 250 psi; 50% of 500 gpm= 250 gpm).
834 - 3. 250 psi (50% at 250 psi).
834 - 4. 200 psi (50% at 200 psi).

835 - 1. The pump must be primed.
835 - 2. One.
835 - 3. The circumference of the impeller disk is greater at the outer edge of the vanes than in the center; therefore, it travels faster. As the water is forced outward from the center of the disk by the centrifugal force, its velocity is increased by the faster turning curved impeller vane.
835 - 4. The distance between the outer edge of the impeller and the wall of the casing.
835 - 5. The volute enables the pump to handle the increasing quantity of water while not affecting the water's speed.
835 - 6. There are no valves within the pump itself.

836 - 1. Single-stage.

565

836 - 2. It changes the operation of the two-stage centrifugal pump (from series to parallel, and from parallel to series).
836 - 3. A hand wheel located on the pump control panel.
836 - 4. Parallel.
836 - 5. It should be turned counterclockwise until it is fully open. There is no set number of turns, just be sure it is fully open.
836 - 6. A one-way check valve which is operated by the pressure of the water flowing over it.
836 - 7. Series of pressure.

837 - 1. When excessive pressure (as determined by the relief valve setting) surges are encountered on the discharge side of the pump.
837 - 2. When the pressure on the discharge side of the pump exceeds that of the relief valve tension spring, it causes a valve to open to relieve the excess pressure.
837 - 3. By turning the screw control cap.
837 - 4. The water flows back into the intake side of the pump.
837 - 5. The pressure on the valve allowing the water into the intake side of the pump is lessened, thereby allowing the pressure of the water in the discharge side of the pump to close the valve, stopping the flow of water to the intake side of the pump.

838 - 1. An access plate is provided behind the right seat to allow checking these levels without tilting the cab.
838 - 2. A foot pump on the floor of the cab.
838 - 3. To signal the cab from the rear platform.
838 - 4. A four-wheel, two-wheel drive (4x2) commercial Ford chassis with dual rear tires.
838 - 5. 199 horsepower at 3800 rpm. 391 cubic inches.
838 - 6. It permits delivery of water from the fire pump for cooling the engine liquid coolant.
838 - 7. The engine radiator when driving, and by the fire fighting water when pumping.
838 - 8. High gear
838 - 9. The transmission is automatically locked into high gear by a valve mounted on the left side of the transmission. The main transmission fluid pressure is then directed through the valve to the governor port to boost the pressure, thus, holding the transmission in high gear.

839 - 1. A two-stage centrifugal pump.
839 - 2. A manual shift is used to engage the pump to acquire power from the engine.
839 - 3. -20° F.
839 - 4. Six. One is connected to each of the four discharge valves and each of the two preconnects.
839 - 5. The baffle partitions are installed in the water tank to prevent side-sway (longitudinal surges) while the vehicle is in motion. They are installed in the foam tank for the same reason as the water tank and to also prevent excessive foaming of the liquid. The baffles work when the agent tanks are full or partially filled.
839 - 6. It may be filled by pressure through the fire pump or through the tank top filler.
839 - 7. 55 gallons.
839 - 8. An around-the-pump type.
839 - 9. By means of a check valve installed between the metering valve and venturi.
839 - 10. A total of 400 feet of 1-inch diameter hose is provided. (One hose reel on each side above the pump compartment contains four 50-foot lengths of hose.

840 - 1. Five groups which are (1) 1½-inch hose; (2) 2½-inch hose; (3) relay; (4) master lines; and (5) varying factors to consider in each lay.
840 - 2. Seven.
840 - 3. One-half pound (one pound for each 2 feet of rise).
840 - 4. Compute the pressure for *one line only.*
840 - 5. The gallon-per-minute discharge of the nozzle or nozzles whichever may be the case.
840 - 6. Dial 700 feet in the total hose lay window, read the indication appearing above the ⅞-inch tip or 106 pounds, because the tip discharges one-half that of a 1½-inch tip. Add 13 pounds, the friction loss in the single line to the tip, to the 106 pounds for a total psi of 119 pounds.

841 - 1. The engine should be stopped to prevent damage caused by lack of lubrication.
841 - 2. By pulling up the brake handle and twisting it to lock.
841 - 3. Drive (D) position.
841 - 4. The hydrant and auxiliary suction valve, if used are opened.
841 - 5. After determining pressure above 150 psi is needed.
841 - 6. 50 psi.
841 - 7. 30

842 - 1. At least two feet.
842 - 2. 1300 to 1500 rpm.
842 - 3. No more than 30 seconds.
842 - 4. The pump should be operated from a fresh water source to flush contaminants from the pump and piping.
842 - 5. The water tank suction line valve.
842 - 6. From any of the discharge hoses.
842 - 7. 200 GPM.
842 - 8. By opening the foam system valve.
842 - 9. To prevent any corrosive action which may be created by the foam solution.

843 - 1. To prevent accidental tilt of the cab.
843 - 2. 600 gallons.

843 - 3. Gasoline.
843 - 4. To increase the angle of descent.
843 - 5. A semi-automatic, hydraulically operated transmission with six forward and one reverse gear.
843 - 6. It enables the truck to operate with either front and rear axle drive or rear axle drive only.
843 - 7. 500 rpm.
843 - 8. Vacuum assist, hydraulically operated, internal expanding shoe type.
843 - 9. The mechanically operated friction type installed on the transfer case.

844 - 1. An electrically actuated clutch is utilized to engage the power takeoff to acquire power from the truck engine.
844 - 2. 200 psi.
844 - 3. The desired flow and pressure at the lowest engine speed is the usual guide.
844 - 4. Electric.
844 - 5. 55 gallons.

845 - 1. The fire pump and pump drive clutch may be damaged.
845 - 2. By pulling the pump clutch control.
845 - 3. One inch booster hose.
845 - 4. The maximum volume of water from the hydrant is being delivered.
845 - 5. The water main(s) will be damaged.
845 - 6. The engine speed increases with NO increase in pump pressure.

846 - 1. In volume.
846 - 2. It indicates that water is entering the pump.
846 - 3. Open the auxiliary cooling valve.
846 - 4. Check for air leaks or clutch slippage.
846 - 5. When the volume does not exceed 250 GPM, and the desired pressure is greater than 100 psi.
846 - 6. 30 psi. To release heated water from the pump to prevent overheating.

847 - 1. When being operated from the water tank.
847 - 2. When lower engine speed is desired.
847 - 3. By switching from volume to pressure periodically.
847 - 4. A draft, a hydrant, or the water tank.
847 - 5. The discharge GPM, hose line layout, and foam strength.

CHAPTER 4

848 - 1. The front-mounted winch.
848 - 2. The power saw, air breathing apparatus, portable electric lanterns, and hydraulic jack.
848 - 3. By either spring loaded brackets or retainers.
848 - 4. The power is transferred directly to the transmission through a dry disc clutch.
848 - 5. A manually operated, four-speed model with four forward and one reverse gear.
848 - 6. It transmits power to the front and rear axles and powers the front-mounted winch through a power takeoff unit.
848 - 7. Vacuum-assisted hydraulic service brakes and mechanical internal-expanding type parking brake.
848 - 8. 50 gallons. Located at the rear of the vehicle under the frame.
848 - 9. 12 volts. A single 70-ampere-hour battery and an engine mounted, belt-driven, 60-ampere alternator.

849 - 1. Their movement must be approved by the local fire chief and all rescue personnel must be advised of the change.
849 - 2. A normal illumination and a bright illumination.
849 - 3. A quart of each.
849 - 4. Six feet.
849 - 5. Left side compartment, utility body.
849 - 6. Twelve safety pins are stowed inside the left rear door of the utility body.
849 - 7. The one yellow extinguisher.
849 - 8. 12; 6, hard rubber; 6, hardwood.
849 - 9. For wrapping, tying, and girdling.
849 - 10. Six (items 6, 7, 8, 11, 12, and 13 in the tool kit list).
849 - 11. Two 75-foot sections of ¾-inch diameter manila rope.
849 - 12. 8,000 pounds.
849 - 13. The cable is 200 feet of ⅜-inch diameter galvanized aircraft cable terminating in a three-pronged grapnel.
849 - 14. By a shear pin.

850 - 1. You must ensure that the truck is stopped with transmission and transfer case in neutral before engaging the power takeoff lever.
850 - 2. The clutch must be disengaged when selection of transmission gears, transfer case power modes, or power takeoff engagement are accomplished.
850 - 3. Four-wheel, low-range and four-wheel, high range.
850 - 4. Under normal road conditions or with lockomatic hubs disengaged.
850 - 5. To prevent excessive wear on front end components.
850 - 6. 20 miles per hour.
850 - 7. The hubs are hand operated using just the fingers.
850 - 8. By the arrows on the hubs.
850 - 9. Reverse
850 - 10. To replace a broken shear pin, knock out the broken pieces of the pin. Then, align the pin holes and install a new pin.

851 - 1. Two. A dry chemical unit and a Halon unit.
851 - 2. Two.

851 - 3. Purple "K" (PKP).
851 - 4. Class B and C fires and it is very effective for exterior running and flowing Class B fuel fires.
851 - 5. 350 pounds.
851 - 6. An evaporating agent (Bromochlorodifluoromethane).
851 - 7. It is considered very effective on Class B and C fires in interior compartments and aircraft engine fires. It is considered a clean agent for these applications.
851 - 8. 100 feet.
851 - 9. 225 ± 25 psi.
851 - 10. Nitrogen; 2265 psi.
851 - 11. One inch.
851 - 12. 35 feet for the Halon nozzle and 53 feet for the dry chemical nozzle.

852 - 1. Either side.
852 - 2. Lifting to the stop position the dry chemical and nitrogen actuation shafts.
852 - 3. Loosen the reel locking wheel located on the right side of the left hose reel.
852 - 4. All 100 feet of the hose.
852 - 5. By pushing the nozzle control forward.
852 - 6. By returning the actuation shaft to the horizontal position from either side.
852 - 7. Until stream is clear of dry chemical.
852 - 8. The tank valve should be open; and the hose clean-out valve, vent valve, dry chemical valve, and nitrogen valve should all be closed.

853 - 1. By pulling either of the charge valves forward to the full open position.
853 - 2. You must open two valves. One valve pressurizes the halon tank with nitrogen and the other opens the line between the halon tank and the nozzle.
853 - 3. The halon piping and hose line must be cleared immediately.
853 - 4. The charge valves are returned to the closed position; the purge valve is opened and the nozzle is opened until the stream is clear of halon.
853 - 5. There will be an unnecessary discharge of halon.
853 - 6. By a nozzle bracket and tie down.

854 - 1. While they are mounted on the vehicle or after they have been removed.
854 - 2. 2100 psi at 70° F.
854 - 3. 2265. The dry chemical tank valve and hose clean out valve.
854 - 4. To 100 psi with dry nitrogen or dry air.
854 - 5. F_S (full safe/green).
854 - 6. Open the vent valve to insure the chemical tank is depressurized.
854 - 7. Enough to fill to the tip of the tank without compacting the agent.

855 - 1. 680 hp (2 engines with 340 horsepower each).
855 - 2. An area large enough for the 110-foot turning radius.
855 - 3. Fifty gallons.
855 - 4. 48 quarts (each of the 2 engines has a 24 qt. capacity).
855 - 5. Eight hours. (Booster heater fuel consumption is one gallon per hour.)
855 - 6. Centrifugal.
855 - 7. 2.3 minutes.

856 - 1. You should open the water tank filler cover and remove the cap.
856 - 2. One impeller (double-suction).
856 - 3. It provides circulation for cooling the fire pump when it is on standby operation, provided the pump is operated at high enough pressure for the relief valve to operate.
856 - 4. When checking the adjustment of the relief valve or when pressure in excess of the maximum pilot valve settings are required.
856 - 5. They provide the entry point for foam to enter the water system. It is at this point that the foam and water start to mix.
856 - 6. There are three strainers and they are located one in each line to the three discharge nozzles.
856 - 7. The roof turret will elevate 70 degrees and the bumper turret will elevate 30 degrees.
856 - 8. To flush the P-2, you must close the foam suction line and place all discharge nozzles in position for foam operation. Open the flush valve and engage the water pump and accelerate to 100 psi discharge pressure with all nozzles open. Allow the pump to operate until the system is completely clear.
856 - 9. They are under pressure any time the water pump is in operation.

857 - 1. Through openings in the roof or the pressure fill line at the rear of the truck.
857 - 2. To close the line while the foam system is being flushed with water and to admit foam solution to the foam pump during foam discharge operations. It is hydraulically operated by controls located in the cab or, in an emergency, manually from the pump compartment.
857 - 3. It gets its power from the pump engine through the same gear box as the water pump. It is driven by a twin disc dry type clutch.
857 - 4. There are two pressure regulators the purpose of which is to sense pressure within the water and foam piping and proportion or regulate the quantity of liquid foam according to the water pressure.
857 - 5. There are three foam discharge valves which are operated by air pressure from the truck air system.

857 - 6. You must loosen the set screw on the metering valve located behind the left rear crewmember's seat and rotate the control knob clockwise.

858 - 1. Engage the water pump.
858 - 2. By extending the spring loaded portion.
858 - 3. The dispersion control lever (7) will be back, the agent selector lever (8) will be back and the rate control lever (9) will be forward.
858 - 4. To prevent excessive wear and damage to the gears.
858 - 5. The two decontrol valves must be in the up position and the turret discharge valve must be opened using the manual discharge valve lever.
858 - 6. By depressing the button on the end of the turret operating handle, moving the turret discharge valve switch to the off position, or manually closing the discharge valve.
858 - 7. There are none. the bumper turret is operated manually only.
858 - 8. By pushing down on the agent selector control handle and pulling out on the dispersion control handle for the bumper turret.
858 - 9. On the pump control panel behind the foam pump control.
858 - 10. By the amount of pressure applied to the squeeze lever located just forward of the nozzle-to-hose connections.

859 - 1. Zero.
859 - 2. The water tank suction valve must be closed and a 4½-inch suction hose must be connected to the 4½-inch intake and the intake valve opened.
859 - 3. By using the hand throttle in the cab.
859 - 4. Closed.
859 - 5. An air pocket will form.
859 - 6. Foreign matter may seriously impair pump efficiency and service life.
859 - 7. Off.

860 - 1. One, diesel
860 - 2. An escape hatch is provided in the cab roof.
860 - 3. As a 6x6 all wheel drive, with rear mounted engine.
860 - 4. One is for the vehicle drive line and one for each of the pumps (water and foam).
860 - 5. Quick disconnects are provided on all hydraulic, fuel, and water lines, and on all electrical wiring.
860 - 6. An amber light warning system is provided on the cab instrument panel and structural control panel.
860 - 7. The operator controls the slippage.
860 - 8. The transmission is a six-speed, semi-automatic (power shift) type with a built-in torque converter.
860 - 9. To provide for some difference in front axle speed and rear axle speed (as when negotiating turns).
860 - 10. Air pressure is used to provide a power boost for the vehicle operator's braking effort.
860 - 11. It is mounted on the transmission output shaft. The fail-safe feature allows a large spring built into the chamber to apply the parking brake automatically when there is a loss of air pressure in the brake system.
860 - 12. Four.
860 - 13. To allow a rapid build-up of pressure for safe operation of the brake system.
860 - 14. A pressure switch will accuate an electrical buzzer whenever air pressure falls to a point where the brakes cannot be operated safely.
860 - 15. 24 volts by four 12-volt batteries connected in series-parallel and a 28-volt engine driven alternator to supply current to the batteries while the engine is operating.
860 - 16. 90,000 BTU - diesel fuel.
860 - 17. 180° F to 200° F.
860 - 18. 40 gallons of diesel fuel.
860 - 19. In a compartment just behind the cab on the upper left side of the body.

861 - 1. Water tank, 1500 gallons; foam tank, 180 gallons.
861 - 2. Roof turret, 800 gpm; bumper turret, 300 gpm.
861 - 3. 60 mph.
861 - 4. By a clutch on the power divider.
861 - 5. To provide for easy adjustment and replacement of packings to control leakage.
861 - 6. By a pilot operated regulator; and it is always in proportion to the water pressure.
861 - 7. 105°.
861 - 8. 90°, 70° and 20°.
861 - 9. It is manually operated.
861 - 10. 170° (85° either side of neutral) and 60° (45° elevation and 15° depression from horizontal.)
861 - 11. When approaching an emergency through flames.
861 - 12. Guides to limit the movement of the bumper turret are located on the cab frontal area right and left sides.
861 - 13. Five inch.
861 - 14. Six quarts.
861 - 15. 21 foot.

862 - 1. All controls and instruments necessary for mobile operation.
862 - 2. Brake; 65.
862 - 3. Turn and hold the engine master switch in the shutdown position until the engine stops firing. Then return the master switch to the on position, turn the heat-start switch to the heat position for 30 seconds, and return the heat-start switch to start position while

holding the throttle pedal in approximately half-speed position.
862 - 4. Five minutes at 800 to 1000 RPM.
862 - 5. It is recommended that 1st and 2nd gear be used only for off-road operations, and ascending grades as necessary.
862 - 6. This will result in engine "lugging," overheating, and poor performance.
862 - 7. When slowing or stopping the vehicle on level ground.
862 - 8. Differential action in the axles.
862 - 9. While operating at high speeds, in sharp turns, or if one wheel is spinning or slipping.
862 - 10. The engine should be operated at a fast idle (1000 to 1200 RPM) for three to five minutes to stabilize engine temperature, and further allowed to idle at normal idle for 30 seconds before engine shut-down to prevent damage to the turbocharger.
862 - 11. Until the engine stops completely.
862 - 12. At water position.

863 - 1. The equipment operator's position.
863 - 2. None.
863 - 3. After the vehicle is at a complete stop.
863 - 4. 225 to 275 psi.
863 - 5. Water or foam.
863 - 6. A solenoid valve in the bypass hydraulic circuit will close and pressurize the turret hydraulic system.
863 - 7. Two foam.
863 - 8. 160 feet.
863 - 9. Shut off the discharge valve switch and place the agent selector to off position.
863 - 10. 125 feet in solid pattern, 60 feet in dispersed high velocity), and 30 feet in dispersed (low velocity).
863 - 11. Pull upward on the velocity control knob.
863 - 12. Neutral, 2000 RPM.

864 - 1. Any and all.
864 - 2. From the structural control panel on the left side of the truck.
864 - 3. At either the hydrant or the scene of the fire.
864 - 4. By an individual depressing the hose lay signal button on the side of the engine cover.
864 - 5. A definite change in the sound of the priming pump will be heard and water discharge will be seen from the priming pump discharge line underneath the vehicle.
864 - 6. 1000 RPM.
864 - 7. Engaging the water pump clutch by means of the structural panel control will engage an interlock system, preventing the transmission from being shifted out of neutral.
864 - 8. The data plate on the structural control panel.
864 - 9. Off.
864 - 10. The roof turret hydraulic system must be by-passed during structural operations to prevent fluid overheating.
864 - 11. The 2½-inch inlet(s).
864 - 12. Water is being discharged faster than it is being supplied to the pump. Lower the pump speed or shut off one or more nozzles to lower the discharge rate to prevent loss of prime.

865 - 1. The concentrate is very expensive.
865 - 2. From inside the small body compartment located directly over the left rear wheel well.
865 - 3. It is advisable to perform a flushing of the piping to remove all traces of the foam concentrate which is very corrosive.
865 - 4. The manifold drain valves are at the low points in the lines. These valves are located in the nozzle and water pump compartment.
865 - 5. From overhead and from hydrant.
865 - 6. 75.
865 - 7. 1½-inch.

CHAPTER 5

866 - 1. A fixed two-way radio.
866 - 2. The chief must be able to respond immediately to any situation so that he may be "on top" of the situation from the beginning.
866 - 3. All.
866 - 4. The chief's vehicle must be available to the chief at all times, and the assistant fire chief for operations has his own duties which require mobility via vehicle.
866 - 5. In case the chief cannot respond to an incident, the assistant will function in place of the chief and should therefore have his own vehicle and equipment.
866 - 6. Normally the only equipment common between them is the communications and emergency warning equipment.
866 - 7. A hoisting device may be installed in the bed of the vehicle.
866 - 8. To mobilize the inspection teams and assist in the maintenance of fire extinguishers.

867 - 1. Five.
867 - 2. When the vehicle is to be driven over rough terrain, up steep inclines, through mud or snow, or over ice.
867 - 3. 8 to 24 feet.
867 - 4. 29,000 pounds. You should take vehicle weight into consideration when stopping the vehicle, before crossing bridges, and when driving over unimproved surfaces.
867 - 5. 13 inches.

868 - 1. Commercial.
868 - 2. Fuels servicing.
868 - 3. Foaming of runways and handling of fuel spills.

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STOP-

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

57150 05 22

FIRE PROTECTION VEHICLES

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers.* The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (800) How would you set the automatic choke on a vehicle for starting in very cold weather after the vehicle has been outside overnight?

   a. Pull the choke control knob all the way out and turn clockwise to lock.
   b. Pull the choke control knob halfway out, turn on starter switch, pull knob to full out.
   c. Manually move choke plate "butterfly" into the vertical position and lock control knob in the CLOSED position.
   d. Depress the accelerator to the floor and release.

2. (800) Which of the following causes oil dilution to take place in your engine?

   a. Loose fan belts.
   b. Worn main bearing.
   c. Excessive idling.
   d. Using the wrong grade of gasoline.

3. (801) Which one of the following practices would not be considered misuse while operating a vehicle with a 5-ton chassis equipped with a manual transmission?

   a. Pausing at the "friction point" before release of the parking brake when putting the vehicle in motion.
   b. Depressing the clutch pedal to allow the vehicle to coast at a high rate of speed.
   c. Applying very light pressure to the clutch while underway to determine if the clutch is slipping.
   d. Holding the clutch pedal on the floor for a half hour while waiting for traffic to clear from an accident.

4. (801) Downshifting should be avoided above what speed when stopping or preparing to make a turn?

   a. 5 mph.
   b. 10 mph.
   c. 15 mph.
   d. 20 mph.

5. (802) When properly positioned for driving in a straight line, no turns, your left hand should be where on the steering wheel?

   a. At the 2 o'clock position.
   b. At the 4 o'clock position.
   c. At the 10 o'clock position.
   d. On the most nearly vertical wheel spoke.

6. (802) Which gear should you select for initial movement on a slippery surface?

   a. 1st.
   b. 2nd.
   c. 4th.
   d. 5th.

7. (803) Vehicle brakes have their greatest stopping power at what point?

   a. Just before the wheels lock.
   b. At the instant full pressure is applied.
   c. During the pause between pumps.
   d. Just after pressure is released from the pedal.

8. (804) As an average driver, you should have a braking reaction time of

   a. one-fourth second.
   b. one-half second.
   c. three-fourths second.
   d. one second.

9. (805) If you are in an area where U-turns are illegal and you must turn around, what is the best type of turn to make when conditions permit?

a. Curb-to-curb.
b. Road turn to the right.
c. Road turn to the left.
d. Backing road reverse.

10. (806) When parallel parking a vehicle 20 feet long, you should select an area at least how long?

a. 23.5 feet.
b. 27 feet.
c. 25 feet.
d. Any lenth over 21 feet.

11. (807) Which one of the following is especially important in controlling your speed?

a. Sight distance.
b. Tires with at least 3/32-inch of tread.
c. Well adjusted brakes.
d. All four headlights burning.

12. (807) In which one of the following situations would slow speed be most dangerous?

a. On the approach to a half-mile long bridge.
b. Being 440 yards down a mile long grade.
c. Just after clearing roadway going onto an interstate highway ramp.
d. Just after you have cleared a sharp curve or crested a hill.

13. (808) If it takes 5 pounds of force to turn a given vehicle at 20 mph, how many pounds of force will be needed at 60 mph in the same vehicle to make the same turn?

a. 5.
b. 15.
c. 30.
d. 45.

14. (809) If the vehicle in front of you obstructs your vision of the road ahead, it is an indication that

a. the other vehicle is going to slow.
b. you are following too close.
c. the driver of the other vehicle is unsure of where they are.
d. you must pass the other vehicle quickly.

15. (810) The safe rule for following another vehicle is to allow

a. 2 feet of distance for each mile per hour of speed.
b. 1 1/2 feet of distance for each mile per hour of speed.
c. 1 foot of distance for each mile per hour of speed.
d. enough room for the vehicle following you to get back into line if it tries to pass.

16. (811) When passing a vehicle which is traveling at 40 mph, you should be traveling at least how many miles per hour to safely pass within safe limits?

a. 45.
b. 48.
c. 55.
d. 65.

17. (812) The sound of your horn will have what effect upon the driver of the vehicle you are passing?

    a. The driver of the car being passed must slow their vehicle.
    b. The driver of the vehicle being passed must maintain a speed equal to that of the vehicle passing at the time the horn was sounded.
    c. The driver of the vehicle being passed is put under a legal obligation to help you pass.
    d. The driver of the vehicle being passed must steer to the left side of the road and wait until the vehicle passing has cleared them by 500 feet before accelerating.

18. (813) When being passed, why should you maintain a constant speed?

    a. So the driver passing you won't have to increase speed to pass.
    b. To allow the other driver to judge the passing distance with greater accuracy.
    c. To allow the other driver to cut back into traffic without hitting you.
    d. So you will be better prepared to slow to allow the other driver back into traffic when they are along side you.

19. (814) Which of the following actions would be the best step to take when an emergency vehicle approaches from the rear with the emergency lights on?

    a. Drive to the right-hand curb and stop until the emergency vehicle has passed.
    b. Drive to the left side of the street and stop.
    c. Drive to the center of the street and slow down.
    d. Wait until the emergency vehicle driver signals to pass and then react as you would for normal passing.

20. (815) If you cannot get your vehicle off the road because of a breakdown, how far down the road should you walk to warn oncoming drivers of the danger?

    a. 50 feet.
    b. 100 feet.
    c. 500 feet.
    d. As far as necessary to warn in time.

21. (816) To avoid skids on slippery surfaces, you should

    a. start out fast for better traction.
    b. turn sharply for better control.
    c. start, turn, and stop slowly.
    d. skids are unavoidable on slippery surfaces.

22. (817) If you run off the pavement, you should

    a. steer straight and slow gradually.
    b. turn sharply to get back on.
    c. stop immediately.
    d. maintain speed and ease back on.

23. (818) The worst accident to be involved in is a

    a. rear-end collision.
    b. head-on collision.
    c. side to side collision.
    d. quartering tail accident.

24. (819) What is the minimum distance an open flame is allowed to a fueling vehicle?

    a. 50 feet.
    b. 30 feet.
    c. 35 feet.
    d. 45 feet.

25. (820) At what part of a fire should the extinguishing agent be directed?

    a. Crown.
    b. Base.
    c. Center.
    d. Head.

26. (821) What operators and vehicles are given access to the flightline?

    a. All vehicles and drivers.
    b. Only those with the permission of base operations.
    c. Only those cleared by the control tower.
    d. Only those designated by the base commander.

27. (821) What evidence do drivers have that authorizes them for flightline operation?

    a. It will be overstamped on his ATC Form 624.
    b. It will be overstamped on his DD Form 18.
    c. It will be overstamped on his DD Form 1360.
    d. None required.

28. (822) Which side of a vehicle should be toward the aircraft when approaching?

    a. Front.
    b. Rear.
    c. Right.
    d. Left.

29. (822) How close may a vehicle come to the runway before obtaining clearance from the control tower?

    a. 250 feet.
    b. 200 feet.
    c. 175 feet.
    d. 100 feet.

30. (823) What signal will you get from the control tower when it is clear to cross a runway?

    a. A blinking red light.
    b. A flashing white light.
    c. A steady green light.
    d. A red and white light.

31. (824) What gear should be used to cross a ditch?

    a. Second.
    b. Third.
    c. Low.
    d. High.

32. (825) What damage will most likely result from stones between dual tires?

    a. Broken sidewalls.
    b. Broken rims.
    c. Underinflation.
    d. Broken spokes.

33. (826) Which of the following would not be used to get a vehicle out of the mud?

    a. Pull out slowly in low gear.
    b. Rock the vehicle.
    c. Get another vehicle to pull you out.
    d. Attach a winch cable to a tree and pull yourself out.

34. (827) To improve your traction when driving on sand, you should

    a. do nothing.
    b. overinflate your tires.
    c. speed up.
    d. reduce tire pressure.

35. (828) Which one of the following will improve traction on an icy surface?

a. Mud.
b. Water.
c. Sand.
d. Grass.

36. (829) Which of the following publications should be used to properly fill out AFTO Form 374?

a. TO 00-20B-5.
b. TO 00-25B-10.
c. TO 00-105E-9.
d. TO 00-172-25.

37. (830) Which of the following series of items should be checked first during the daily inspection of a firefighting vehicle?

a. Agent tanks, equipment, and chassis.
b. Instruments, tires and lugs, and safety devices.
c. Coolant, oil, and fuel levels and drive belts.
d. Safety devices, chassis, and firefighting system.

38. (830) A hydrometer should be used to test/measure specific levels in which of the following items?

a. Coolant/batteries.
b. Coolant/fuel system.
c. Electrical system/lubrication system.
d. Ratio of foam to water/viscosity of the oil.

39. (831) A slightly high temperature gage reading and slightly low ammeter reading on the vehicle you are driving would indicate that the

a. fan belt is not at the recommended tension.
b. brushes in the generator/alternator are bad.
c. bearings in the water pump are worn.
d. engine is being operated at too high a speed.

40. (831) You can say a run is completed when

a. the second before operation inspection is completed.
b. during operation inspection is entered in the forms.
c. after operation inspection is completed.
d. the vehicle is back in service.

41. (832) When filling out a new AFTO form for the inspection of a firefighting vehicle on the first day of October 1977, the entry in the date block of the heading information section should appear as

a. 7274.
b. 1-10-77.
c. 1 October 77.
d. Oct 77.

42. (832) When Jackie B. Borne signifies satisfactory completion of an inspection item on an AFTO Form 433, the entry in the Operator Signature section should appear as

a. J. B. B.
b. J. Borne.
c. Jackie B. Borne.
d. Borne, Jackie B.

43. (833) When filling out a new AFTO Form 434 on the first day of July 1977, the entry in the center section of the form under Date DISC should appear in what manner for open discrepancies discovered in May of 1977?

a. C/F.
b. 1 Jul.
c. May 77.
d. 1 July 77.

44. (833) How do you determine the entry to be made in the Miles/Hours block on the inspection guide?

a. Refer to TO 00-25B-6.
b. Refer to the TO on the particular vehicle.
c. Refer to the vehicle Ser-O-Plate.
d. You must enter both to be correct.

45. (834) A 750 gpm standard rated pumper will deliver how many gallons of water per minute at 200 psi?

a. 375.
b. 525.
c. 750.
d. 1,000.

46. (834) At what pressure does a 1,000 gpm standard rated pumper operate when it delivers only 500 gpm?

a. 120 psi.
b. 150 psi.
c. 200 psi.
d. 250 psi.

47. (834) Earlier standard rated pumpers deliver what percent of their rated capacity at 250 psi?

a. 75 percent.
b. 50 percent.
c. 33.3 percent.
d. 25 percent.

48. (835) Each revolution of the centrifugal pump should discharge how many gallons of water?

a. 2.5 gallons.
b. 16 gallons.
c. 67.3 gallons.
d. no set amount.

49. (835) The velocity of the water being discharged from a centrifugal pump is governed by the

a. thickness of the impeller vanes.
b. rate of rotation of the impeller.
c. size of the pump's volute.
d. clockwise rotation of the impeller vanes through the arc of the volute.

50. (836) When water leaves the first impeller during series pumping operations with a two-stage centrifugal pump, it (the water) is at what percent of the operating pressure?

a. 33.3 percent.
b. 50 percent.
c. 70 percent.
d. 100 percent.

51. (837) When the relief valve on a two-stage centrifugal pump opens, the water released by the relief valve passes from the

a. discharge side of the pump to the intake side of the pump.
b. discharge side of the pump into the booster tank.
c. first impeller of the pump into the discharge side of the pump.
d. intake side of the pump to the supply source to be pumped again.

52. (838) To provide access to the engine and front chassis components, the cab of the P-12 should tilt forward approximately

a. 30°.
b. 45°.
c. 60°.
d. 90°.

53. (836) The flow of water from the fire pump to the heat exchanger is controlled by a

a. thermostatically operated valve, mounted on the heat exchanger.
b. electrically operated valve, mounted on the cab dash.
c. manually operated valve, mounted on the left-hand pump operator's panel.
d. hydraulically operated valve, mounted on the right-hand pump operator's panel.

54. (838) The transmission of the P-12 provides for

a. 2 forward speeds and 1 reverse speed.
b. 4 forward speeds and 1 reverse speed.
c. 4 forward speeds and 2 reverse speeds.
d. 8 forward speeds and 2 reverse speeds.

55. (839) Discharge gages are provided for what number of preconnects on the P-12?

a. 2.
b. 4.
c. 6.
d. none.

56. (839) What is the foam liquid tank capacity on the P-12?

a. 5 gallons.
b. 11 gallons.
c. 55 gallons.
d. 60 gallons.

57. (839) When all booster reel hose provided on the P-12 is connected to make one hose line, the length of that one line should be

a. 150 feet.
b. 200 feet.
c. 400 feet.
d. 800 feet.

58. (840) When using the pressure computer on the P-12, how many factors must be taken into consideration in each lay?

a. 4.
b. 5.
c. 6.
d. 7.

59. (840) When using the pressure computer on the P-12, the most important factor to be taken into consideration is determined by the

a. total discharge in gallons per minute by the nozzle(s).
b. friction loss in the supply line to the master line tip.
c. number of lines used to supply any given tip.
d. maximum rpm at which the pump may be operated without causing damage to the impeller vanes.

60. (841) What is the minimum pressure at which the P-12's relief valve may be set?

a. 50 psi.
b. 75 psi.
c. 100 psi.
d. 150 psi.

61. (841) How can you tell when the relief valve on the P-12 will operate at the set pressure?

a. By advancing the hand throttle until the warning buzzer sounds.
b. By turning the adjusting wheel counterclockwise until the warning buzzer sounds and then turning clockwise one turn.
c. The pilot light will go out when you turn the adjustment wheel clockwise.
d. The relief valve will operate at the pressure set by the computer whenever the pilot light is illuminated.

62. (841) Should the P-12 be shut down for any reason, the water pressure should be decreased to what psi before closing the discharge valves?

a. 100.
b. 70.
c. 50.
d. 30.

63. (842) When pumping from a draft with the P-12, the primer should be operated for a maximum of how many seconds without pump discharge?

a. 30.
b. 35.
c. 40.
d. 45.

64. (842) When pumping from the water tank on the P-12, the transfer valve position should not be changed when the pump pressure exceeds

a. 30 psi.
b. 50 psi.
c. 90 psi.
d. 100 psi.

65. (842) What is the maximum rate of discharge from the P-12 when pumping 6 percent foam solution?

a. 250 gpm.
b. 200 gpm.
c. 350 gpm.
d. 750 gpm.

66. (843) If the level of the water tank of the P-8 is at the half-full mark, how much water will be required to fill the tank to its capacity?

a. 200 gallons.
b. 300 gallons.
c. 400 gallons.
d. 600 gallons.

67. (843) The engine of the P-8 develops what net horsepower?

a. 391 at 3800 rpm.
b. 255 at 3600 rpm.
c. 201 at 3600 rpm.
d. 199 at 3800 rpm.

68. (843) The retarder incorporated within the transmission of the P-8 is manually actuated to

a. assist the service brakes.
b. lock the park brake.
c. engage the power take-off unit.
d. shift the transfer case into low range.

69. (844) On P-8's, except model M46FD, the pump is powered by

a. a hydraulically operated clutch engaging the power take-off assembly.
b. a manually operated clutch engaging the transfer case.
c. a transfer case electrically actuated through the power take-off assembly.
d. an electrically actuated clutch engaging the power take-off assembly.

70. (844) When the pump is operating from a draft, the pressure mode can be used when the

a. volume is less than 250 gpm and desired pressure is in excess of 100 psi.
b. pressure is less than 250 psi and desired volume is more than 500 gpm.
c. volume is more than 250 gpm and desired pressure is at least 250 psi.
d. pressure is less than 150 psi and desired volume is no more than 100 gpm.

71. (844) The pump on the P-8 is designed to operate at up to what net pump pressure in the volume mode?

a. 275 psi.
b. 200 psi.
c. 225 psi.
d. 250 psi.

72. (845) The pressure computer on the P-8 cannot be used to determine pressure for which of the following?

a. 1-inch hose lines.
b. 1 1/2-inch hose lines.
c. 2 1/2-inch hose lines.
d. Master or relay hose lines.

73. (845) What action should be taken to attain the desired pressure from a P-8's pump when the gage indicates a vacuum before the desired pressure is reached?

a. The transfer valve should be turned to the other position.
b. A smaller diameter nozzle tip must be used.
c. The hose line must be shortened by 30 percent and the nozzle tip increased by 1/2-inch in diameter.
d. The pump primer must be engaged for 60 seconds to insure there are no leaks between the hydrant and pump.

74. (845) If the engine speed increases with no increase in pressure, which of the following conditions would be indicated?

a. The volume of water from the hydrant exceeds the capacity of the pump.
b. The pump has developed a leak in the packing at the second stage impeller.
c. The pump is operating faster than the volume of water delivered from the hydrant.
d. The main to the hydrant has been damaged and no water is reaching the first stage impeller.

75. (846) When operating the P-8 from a draft, the transfer valve should not be changed when pressures exceed

a. 25 psi intake.
b. 25 psi discharge.
c. 30 psi discharge.
d. 50 psi intake.

76. (846) If the needle in the vacuum gage fluctuates during a drafting operation, which one of the following actions should be taken?

a. None, as this is common during drafting.
b. Decreased the pressure until the needle holds steady, then very slowly increased.
c. Increased the pressure until the needle holds steady, then very slowly decreased.
d. Adjust the steady valve until the needle holds steady.

77. (847) When may the pump be operated with the truck in motion?

a. When operating from a hydrant.
b. When operating from the water tank.
c. When operating from a draft.
d. The truck must be stationary for pump operation.

78. (847) The valve controlling the flow of water from the pump pressure side to the eductor is the foam

a. metering valve.
b. tank valve.
c. system valve.
d. discharge valve.

79. (848) How many door/panels are there on the utility body of the P-10 for easy access to stowed equipment?

a. 7.
b. 8.
c. 9.
d. 10.

80. (849) What items are stowed on the right rear door of the utility body?

a. Twelve safety pins.
b. The harness cutters.
c. Six hard-rubber and six hardwood plugs.
d. The extension cords for the generator.

81. (849) The winch incorporates which of the following to hold the load on when power is released?

a. An automatic brake.
b. A safety brake.
c. The sear pin.
d. The second clutch.

82. (850) The P-10 should not be shifted into four-wheel drive at speeds above

a. 5 mph.
b. 10 mph.
c. 15 mph.
d. 20 mph.

83. (850) The winch shear pin is held in place in which of the following manners?

a. By centrifugal force.
b. With a cotter pin.
c. With a 3/8-inch set screw.
d. By the dust cover butt plate.

84. (851) With the dry chemical agent tank filled to capacity and the nozzle discharging at its maximum rate, the dry chemical extinguishing unit should empty in approximately how many seconds?

a. 34.
b. 48.
c. 69.
d. 92.

85. (851) To be within the effective range for the dry chemical unit nozzle on the P-13, you must be within what distance of the fire?

a. 88 feet.
b. 74 feet.
c. 53 feet.
d. 35 feet.

86. (852) To actuate the dry chemical nozzle on the P-13, you must

a. pull the trigger.
b. squeeze the handgrip lever.
c. push the nozzle control forward.
d. pull the nozzle control to the rear.

87. (852) To shut down the dry chemical unit on the P-13, the dry chemical valve is closed by returning the actuation shaft to the

a. vertical position from the left side only.
b. horizontal position from the right side only.
c. standby position from either side.
d. horizontal position from either side.

88. (853) You must manually open how many valves to activate the Halon 1211 system when the charge valve torque tube is broken?

a. 1.
b. 2.
c. 3.
d. None, system will not activate.

89. (853) The vent valve in the P-13 Halon 1211 system is opened during securing operations to

a. clear the piping of halon.
b. relieve excess pressure on the intake side of the regulator.
c. relieve pressure from the halon tank.
d. prevent halon from backing into the nitrogen cylinder.

90. (854) If while recharging a P-13 halon unit nitrogen cylinder, it, the cylinder, is by mistake filled to the rated capacity for the dry chemical nitrogen cylinder, then the halon unit nitrogen cylinder will have how much, if any, excess pressure?

a. None.
b. 70 psi.
c. 100 psi.
d. 165 psi.

91. (854) During recharging of the dry chemical tank on a P-13A, when should the vent valve be closed?

a. Before the operation begins.
b. When operation is complete.
c. After the tank cap is removed.
d. After the first 200 pounds of agent is added.

92. (855) A full water tank on the P-2 can be emptied in how many minutes by using only the bumper turret discharging at its maximum rated capacity?

a. 1.64.
b. 2.30.
c. 7.66.
d. 23.0.

93. (855) The engine on the P-2 used for pumping is governed at what speed for pumping?

a. 1,800 rpm.
b. 2,400 rpm.
c. 2,500 rpm.
d. 2,800 rpm.

94. (856) Foam is mixed with water at the

a. inductors.
b. strainers.
c. discharge valves.
d. intake side of the pump.

95. (856) To assure positive escape of air from the water tank on the P-2 while filling from a pressure source, you should

a. insure the check valve is open.
b. open the tank cover and remove the cap.
c. regulate intake pressure to 25 psi or less.
d. be sure that the check valve is fully operational.

96. (857) The foam tank on the P-2 is made of what material?

a. Fiberglass.
b. Stainless steel.
c. Aluminum.
d. Rubber.

97. (857) The foam system on the P-2 includes how many foam metering valves and pressure regulators (proportioners)?

a. Four metering valves and three pressure regulators.
b. Three metering valves and two pressure regulators.
c. Two metering valves and no pressure regulators.
d. Two of each.

98. (857) The foam discharge valves are operated by

a. mechanical linkage.
b. electric motors.
c. hydraulic pressure.
d. air pressure.

99. (858) The last action required to discharge agent from the P-2 handline nozzle during normal operation, is to

a. open the discharge valve in the nozzle compartment.
b. select the desired stream using the lever on the left side of the nozzle body.
c. select the desired agent to be discharged (foam water or water only).
d. exert pressure against the lever mounted just forward of the nozzle-to-hose connection.

100. (859) Before engaging the water pump on the P-2 when pumping from relay, the water tank suction valve control (X) and 4 1/2-inch intake valve handle (Z) must be in what positions?

a. X—horizontal, Z—parallel to the intake.
b. X—vertical to its valve, Z—horizontal.
c. Z—vertical to the pump, X—parallel to the pump impeller.
d. Z—horizontal, X—parallel with Z.

101. (859) While operating the P-2 from a hydrant, foam can not be discharged through the installed foam system from which one of the discharge devices?

a. Handline.
b. 2 1/2-inch hose line.
c. Roof turret.
d. Bumper turret.

102. (860) The vehicle body of the P-4 is mounted in sections which are the

a. cab, center body, and rear body.
b. cab, water tank body, foam tank body, and engine compartment.
c. crew and equipment section, pump(s) and piping section, and power train section.
d. crew compartment, right-half center section, left-half center section, power train section.

103. (860) Which of the following items are installed in each drive engine cylinder on the P-4 as aids in cold weather starting?

a. Injectors.
b. Dual sparking plugs.
c. Glow plugs.
d. Head bolt heaters.

104. (860) The drive to the main transmission is controlled by the

a. collector gearbox.
b. torque converter.
c. transfer case.
d. power divider.

105. (860) Air pressure from the P-4 air pressure system is required for operation of all of the following except the

a. windshield wiper motors.
b. front hose reel rewind motor.
c. engine cover closing/locking mechanism.
d. treadle valve to power clusters.

106. (860) An overheat switch should shut down the booster heater on the P-4 when the heater continues to operate at temperatures above

a. 100° F.
b. 150° F.
c. 200° F.
d. 215° F.

107. (861) Which one of the following vehicles uses a 5-inch intake manifold on which the water pump is mounted?

a. P-2.
b. P-4.
c. P-8.
d. P-12.

108. (861) What size ladder is supplied on the P-4?

a. 12-foot ladder.
b. 21-foot ladder.
c. 24-foot ladder.
d. 35-foot ladder.

109. (862) How long should the P-4 engine be at low idle before the engine is shut down?

a. 30 seconds.
b. 1 minute.
c. 3 to 5 minutes.
d. No certain time, just let the engine smooth out before shut down.

110. (862) When flushing the P-4 foam system, which of the following agent dispensing devices should be opened for discharge?

a. Roof turret.
b. Bumper turret.
c. Handline nozzle.
d. All of the above.

111. (863) When engaged, the roof turret hydraulic system pressure is normally

a. 350 to 500 psi.
b. 500 to 600 psi.
c. 600 to 750 psi.
d. 750 to 1,000 psi.

112. (863) At low velocity, the P-4 bumper turret should have an effective range of how many feet?

a. 20.
b. 30.
c. 60.
d. 85.

113. (864) Where is the hose lay signal button located on the P-4?

a. Top center of the engine cover.
b. On the side by the pump control panel.
c. On the side of the engine cover.
d. Inside the left 2 1/2-inch hose bed.

114. (864) When pumping from a nurse truck, the discharge from the nurse truck should be connected to which inlet on the P-4?

a. Right side 5-inch inlet.
b. Either side 4 1/2-inch inlet.
c. Left side 2-inch inlet.
d. Either side 2 1/2-inch inlet.

115. (865) The main tank water drain valve on the P-4 is located over the

a. right front axle.
b. forward rear axle.
c. back rear axle.
d. right master intake control lever.

116. (865) What size hose is used to pressure fill the P-4 foam tank through the connection at the rear of the truck?

a. 1 inch.
b. 1 1/4 inches.
c. 1 1/2 inches.
d. 2 1/2 inches.

117. (866) Which one of the following positions/sections is not normally authorized a pickup for their own official use?

a. The fire chief.
b. The assistant fire chief for operations.
c. The assistant fire chief for training.
d. The technical services section.

118. (866) The fire chief's vehicle must be made available for use

a. 8 hours a day for any 5 days in 1 week.
b. 0730 to 1630 hours Monday through Friday.
c. during those hours when the chief is physically in the station.
d. at all times.

119. (866) You would normally expect to find a hoisting device installed in the bed of a pickup assigned to the

a. fire chief.
b. shift on duty.
c. technical services section.
d. assistant fire chief on duty.

120. (867) Air Force bases are authorized tankers based upon the

a. square foot area of the base.
b. fuel capacities of mission assigned aircraft.
c. number of aircraft and crew/passenger load.
d. past requirements for firefighting water in areas not supplied by the water distribution system.

121. (867) A 1,000-gallon water tanker getting 5 miles to the gallon of fuel would be able to travel how far with a full fuel load in the fuel system?

a. 200 miles.
b. 325 miles.
c. 475 miles.
d. 550 miles.

122. (867) When operating the 1,000-gallon tanker over rough terrain, you must insure a ground clearance of how many inches before continuing operations?

a. 7.
b. 10.
c. 13.
d. 15.

123. (868) Which one of the following capacities of tankers has a body and chassis of commercial design and construction?

a. 1,000-gallon tanker.
b. 1,500-gallon tanker.
c. 2,500-gallon tanker.
d. 5,000-gallon tanker.

124. (868) If the tanker you are filling with water is almost empty, only about 200 gallons of water in the tank, and it takes approximately 19,000 pounds of water to fill the tank, which tanker are you filling?

a. The F-7 tanker.
b. The F-6 tanker.
c. The 1,000-gallon tanker.
d. The 1,500-gallon tanker.

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CDC 57150

FIRE PROTECTION SPECIALIST

(AFSC 57150)

Volume 6

Structural Firefighting

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Extension Course Institute

Air University

556

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

YOU ARE NOW starting Volume 6 of this CDC. This means you have learned a lot about fire protection but you haven't completed all your training. We urge you to continue your efforts to complete the course because the practical training given here is essential in your career.

In Volume 6, you will study principles of structural firefighting, hose operations, ladder operations, command and control, and post-extinguishment operations.

Code numbers appearing on figures are for preparing agency identification only.

Please note that in this volume we are using the singular pronoun *he*, *his*, and *him* in its generic sense, not its masculine sense. The word to which it refers is person.

If you have any questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTGOX, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 12 hours (4 points).

Material in this volume is technically accurate, adequate, and current as of July 1979.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit alphanumeric identifier and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Principles of Structural Firefighting

AFTER YOU HAVE responded to several structural fire emergencies, you will be convinced of the great variation in fire conditions and in the procedures for putting out each fire. On the way to the fire and after your arrival there, you and all the other crewmen must quickly analyze the part that each of you must play in the rescue and extinguishment procedures.

1-1. Principles

As you have heard many times in the past and will hear many more times, your primary job is to save lives and protect property. Despite all your efforts at fire prevention, some fires will occur, and when they do occur they must be extinguished. Whether they are extinguished quickly with little loss or they burn for hours with great loss depends primarily on the skill of the senior fire officer in using the forces under his command.

A01. Point out the main features of a good firefighting plan.

Fire fighting is, has been, and always will be one of the main objectives of fire protection. A well-manned, well-equipped, and well-trained department provides a solid base upon which effective fire fighting depends. The strategy and tactics used to suppress fire evolve from this base. The strategy used in fire fighting is to: (1) locate the fire; (2) confine the fire; and (3) extinguish the fire.

All other firefighting actions (tactics) stem from this basic strategy, bringing into play the whole spectrum of personnel, apparatus, equipment, water, and hose. In addition to the basic tactics listed above, you must include rescue (when necessary), protection of exposures, overhaul, ventilation, and salvage. The last three will be discussed at length in later chapters.

Location. Locating the fire sounds like a simple matter. In an open lumber yard where flames are reaching for the sky, it is a simple matter. But finding a fire in a room in a cellar of a three-story dormitory that is filled with dense smoke is no longer a simple problem.

Confinement. Confining the fire is the next step in strategy. Here judgment, skill, and experience must be used to the utmost to help you determine whether or not the fire is to be routine or a disaster. Confining the fire simply means to restrict its spread to its point of origin or at least to the area involved when the fire department arrives. This can mean holding the fire to one room or section in a building, to one floor in a building, or to the building itself. Good strategy may demand that one room is a building be sacrificed (at least temporarily) so that adjoining rooms, or rooms on the upper floors, can be saved. It may also demand that several lines be used to cover exposed fuel tanks while a building burns to the ground.

Extinguishment. Extinguishing the fire may take as little water as that used in a booster line, or it may take thousands of gallons played through heavy appliances. Again the decision rests upon the judgment, skill, training, and experience of the officer in charge. His knowledge of building construction in general and of the particular building on fire will determine his actions. So will his knowledge of the way fire travels, of the effect of time and weather on fire, and of many other matters that he must take into account. Some other facts that must be considered are:

Time of Day. The hour of the day can have a direct bearing on the life and fire hazards involved. Consider, for example, theatres, open messes, schools, shop and hangar areas, offices, etc.

Time also has a direct bearing on the speed of the response of firefighting and rescue vehicles. Traffic congestion at certain hours can all but paralyze vehicle movement. Delayed response, in turn, has a bearing on the equipment needed to control a spreading fire.

If the fire occurs during hours of darkness, special lighting equipment may be needed. Night operations may require auxiliary firefighting personnel.

The season of the year must also be taken into account. Housekeeping in shops and stores may present serious hazards, for there is a tendency to let combustible rubbish accumulate when these establishments are faced with a holiday rush.

Weather. Some of the weather factors that must be considered are: temperature, humidity, wind, and precipitation. The direction of the wind is important because it determines where the greatest exposure dangers are located. The weather itself is of great importance. It includes temperature and humidity, as well as the presence of wind. High humidity means a smoky fire and the difficulty of operating in the building without thorough ventilation. It means, further, in a situation where pungent fumes are encountered, additional hardship and danger for the individuals operating in the street and particularly in narrow alleys at the rear or sides of the fire building. At such a fire, it is frequently impossible to get in close enough to do inside work, and it is necessary to operate from the outside of the building unless suitable respiratory protection is provided. This necessitates the use of larger streams and, if the fire extends to the entire building, deck guns, ladder pipes, and deluge sets. Hence the necessity of noting these points in the size-up. The presence of snow on the tops of buildings eliminates, to a certain degree, the danger of the fire extending to such buildings by means of flying embers. Buildings that have been thoroughly wet by recent rain also provide, to a lesser degree, a resistance against embers as well as against direct exposure from radiation or convection currents.

The accessibility of the fire, including the condition of the street, must be noted. A deep fall of snow means that the equipment will be slower getting to the fire, and the operation will slow up all around, with the result that additional manpower will be required. Excavations or other obstructions in the street in the immediate neighborhood of the fire also have a bearing upon the operation of the fire department, as well as the amount of apparatus and men needed.

Cold weather and ice also hamper the efficient operation of the department by endangering the work of the firefighters on fire escapes, on roofs, or even on streets.

Reviewing the above, you can see that all these factors have a direct bearing upon the vehicles, equipment, and personnel that will be needed. They require careful analysis in making the size-up. The department officer does not have time to make a list of such points, but he must be trained to analyze the situation quickly, make a mental picture of the whole problem and be guided by this picture.

The Fire Building. Other items that you must think about in advance are the fire hydrants, mains, and other water sources.

The Fire. When you arrive at the scene, you must quickly evaluate the following; the extent of the fire, its location in the building, the type of contents involved, the life hazard (for occupants and firefighters), the fire conditions (smoke, gases) and possible need for respiratory protection, rescue equipment, ambulances, medical aid, wrecking equipment (cranes, etc), civil engineer units and personnel, and additional firefighting personnel and equipment.

Location of fire. The location of the fire, both the location of the building and the point within the building where it is burning, cannot be pre-planned, but, without this definite knowledge, nothing can be started.

Type of construction. The type of construction has a great deal to do with the development of the fire. An old services building with open stairways from the ground floor to the top permits a fire to spread with great speed. A modern building with stairwells and elevator shafts in fire-resistive enclosures tends to hold the fire to its point of origin.

Each type of structure has its own characteristics, which must be taken into account by the officer in charge at a fire or in planning. A building characteristic that most fire departments encounter is age. Comparatively few old buildings were built to resist fire, (an exception might be a bank building). Old buildings are apt to have a great deal of woodwork in the form of floor joists, floors, and lath and plaster partitions. Old barracks, BOQs, etc., invariably have a great deal of wood construction throughout including wooden finish around open stairways.

In addition to the structure's age, you must consider type, condition, height, area, large unbroken areas, absence of fire stops, channels for fire travel, such as shafts, stairways, ducts, etc., sprinklers, standpipes, and window protection.

The above constitute but a few of the many points about building construction that the department officer should take into account.

Life hazard. With all of these points in mind, together with information on the occupants of the building, the life hazard can readily be determined the moment the officer makes the size-up. If you roll into a fire in an old converted building now used as a personnel office, you will immediately recognize a serious life hazard, because usually large number of individuals are working in a comparatively small space.

The height of the fire in a building is important. A fire burning in an old building on one of the lower floors usually puts the stairwells and elevator shafts out of commission for the escape of individuals from the upper part of the building. Thus, a fire on one of the lower floors is far more serious from a life hazard standpoint than a fire on the top floor.

Occupancy. In addition to the number of people in the building, you should know the materials that are apt to be found in it. You have to determine this information if it hasn's already been secured through an inspection of the area by tech services personnel in their usual inspection work or in pre-fire planning, note the nature of the units occupying the building.

Refrigerating apparatus, such as found in cold storage plants, commissary butcher shops, and other establishments, may call for special equipment in the form of rescue equipment or for special appliances to enable firefighters to operate within the building.

Exposures. Next, note the exposures. There are two types of exposures: fire exposure and life exposure. Fire exposure refers to the property exposed to the fire, such as property directly across alleys or beside the fire building. Life exposure refers to the danger to the lives of the occupants of any buildings that are in line with the travel of dangerous fumes or gases thrown off by the fire, as well as to the occupants in any building that is seriously exposed to fire from the fire building.

For example, fire is burning in a warehouse, and dense, toxic fumes are thrown off. If these fumes are carried into military family houses, schools, or other occupied buildings, they can cause injury or death.

Additional Help. Following the initial size-up, the fire officer summons whatever apparatus and manpower he thinks necessary. Occasionally, an inexperienced officer calls for too much apparatus, but this is the exception rather than the rule. The analysis of a great number of fires that have destroyed one or more buildings shows that the first-in officer did not appreciate the size of job that his men had to handle with the result that he called insufficient apparatus. Usually, it was only when superior officers arrived and noted the rapidly extending fire that additional apparatus was summoned.

Apparatus is maintained for one purpose alone, and that is for fighting fire. Unless the department is very much overworked, little harm results from calling more apparatus than is needed, and great good may result. If more apparatus than in needed is called, it is a simple matter to dismiss the crews and have them return to their stations with very little loss of time. On the other hand, if too little apparatus is called immediately, by the time additional apparatus is summoned and reaches the scene, the fire may have reached such proportions that a greater number of crews are needed for a longer period of time.

Exercises (A01):

1. The senior fire officer in command must plan the strategy used in firefighting. What is the basis of this plan?

2. The other actions called tactics deals with

3. Define confinement.

4. What are some of the weather factors to consider?

5. List the details about the fire building that can be considered in advance.

6. What must you evaluate about the fire when you arrive at the scene?

7. What factors of building construction must you evaluate when you arrive at the scene?

1-2. Hose Tools, Structural Handtools, and Rope

Structural firefighters must be completely familiar with hose tools. In this section we will discuss the more common hose tools and the maintenance of handtools in general.

A02. Complete statements about hose tools and general handtool maintenance.

Universal Thread Adapter. The universal thread adapter is a very useful tool on any fire vehicle. It can make a quick connection to damaged or unusual-sized male hose connections. A connection can be made even if the threads are worn, untrue, or nonstandard, if the body is out-of-round; or even if the connection is an odd size. On one side of the adapter is a standard 2½-inch male connection with National Standard threads, as shown in figure 1-1. On the

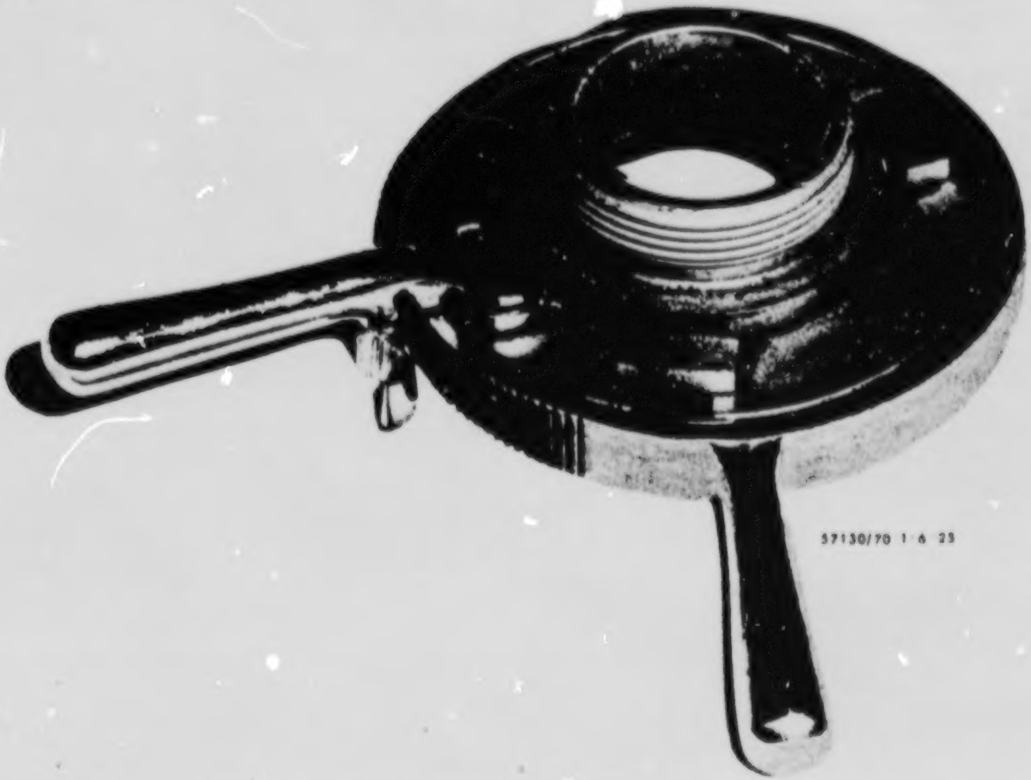

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Figure 1-1. Universal thread adapter.

same side, two handles with a catch release operate three jaws on the opposite side. You open and close the jaws by moving the handles together or away in a scissors-type action. On the same side as the jaws and just behind them is a rubber seat. The jaws can open to a maximum of 3½ inches and close to a minimum of 2 27/32 inches.

To use the adapter, release the catch and open the jaws by moving the handles away from each other. Then place the adapter over the damaged, differently threaded, or unusual-sized male coupling so that the coupling is tight against the rubber seat of the adapter. The rubber seat makes the connection watertight. Finally, you move the handles toward each other firmly, locking the jaws into the male connection threads. The catch will automatically adjust to the locked position while you are doing this. Now you are ready to connect a female coupling to the standard connection on the opposite side of the adapter. The universal thread adapter is not limited to use on hydrants and firehose. You can use it on any connection that has a diameter within the size limits previously mentioned.

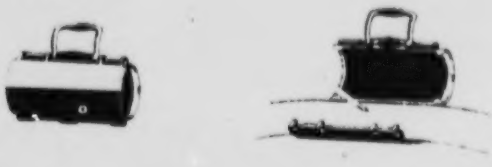

Figure 1-2. Hose jacket.

To maintain this tool, you must replace the rubber gasket seal when it becomes hard, grooved, or cut. A light oiling of moving parts, a daily visual check, and periodic operation are all that are needed. The tool is usually chrome-finished and does not require extensive precautions against rust accumulations or corrosion.

Hose Jacket. The hose jacket is a hollow cylindrical or barrel-shaped device that opens lengthwise through the center on a set of hinges. It is rubber-lined to make it watertight. Figure 1-2 shows how the jacket is placed on the hose. When the jacket is clamped around the leaking portion of a hose or over a leaking hose connection, the water is confined by the hose jacket. This tool can prevent the complete escape of water from a vital hoseline and can prevent the disablement of the entire hose layout.

Even this simple tool can be dangerous if not used properly. To place the jacket around a leaking fire hose, you should approach the hose from the side away from the escaping water stream, lift the hose, and place it in the lower jaw of the jacket, as also shown in figure 1-2. Use your foot to move the upper jaw to close around the hose. A firm push with your foot will lock the jaws together with the least danger

The jaws of the hose jacket are hinged and spring-loaded. A light oiling of the hinge and spring prevents binding. The inner jacket of the tool is rubber-lined and needs a periodic application of neat's-foot oil to keep it pliable. The structure itself is usually made of cast aluminum and painted. Use care when you are painting it and do not clog the spring, hinges, or jaws. Give this tool a daily visual check and a periodic operational check, and it will be ready for use when you need it.

Hose Clamp. The hose clamp, seen in figure 1-3, is the tool you use to stop the flow of water in a firehose without shutting off the source of supply. Two of its uses are to stop the flow of water through a hose while a hose lay is being completed, and to cut off the flow of water in a charged line. You may need to replace a burst section of hose and to stop the flow while the hoselines are extended. Apply the hose clamp to a section of hose approximately 6 feet from the coupling, if possible. Hose clamps sometimes damage the hose, and replacing the damaged portion (6 feet or so) does not seriously decrease the length of a hose section. As you apply the hose clamp, you should stand at the base end and either raise or lower the locking lever. Whether you raise or lower the lever to shut off the line depends upon the type of hose clamp you are using. Always apply and release hose clamps with a smooth, steady action, neither too slow nor too fast. A sudden decrease or increase of pressure can upset someone handling a nozzle along the hose lay. Too slow a shutoff can slide the clamp along the hose. The maintenance of this tool is rather simple. A daily check for proper operation and a complete visual check will assure its satisfactory operation during an emergency. When you are painting this tool, do not clog any scissor action levers or locking teeth. Apply a light coating of oil at any point of wear.

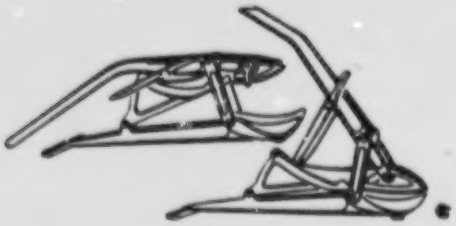

Figure 1-3. Hose clamp.

Spanner and Hydrant Wrenches. The spanner wrench is used to tighten leaking connections and to loosen connections that are too tight to "break" with the hands alone. Figure 1-4 shows how these wrenches may be used. Spanner wrenches are designed to fit either rocker-type or pin-type hose coupling lugs, or both. The handle of the spanner wrench is tapered so that you can use it as a hand-prying tool, as shown in figure 1-5. Some handles are designed to close gas cocks. Notice in figure 1-6 that there are spanner wrenches to fit almost all types and sizes of firehose fittings, from the smallest chemical hose to the largest suction hose.

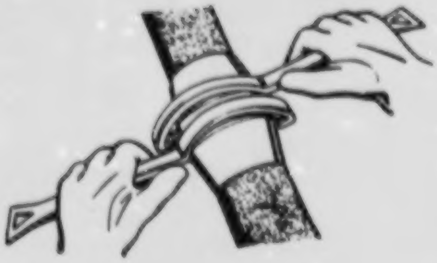

Figure 1-4. Using spanner wrenches.

Hydrant wrenches are used to open and close fire hydrants and to remove hydrant caps. Some are designed to tighten or loosen coupling connections. The many types of hydrant wrenches include those that are fixed and those that are adjustable. The hydrant wrench, shown in figure 1-7, is an adjustable wrench. The maintenance of hydrant and spanner wrenches is simple and easy. Make the daily visual check to be sure that the proper number and types are on each firetruck. (Comics have worn out the jokes about the fireman who forgot his hydrant wrench.) Make sure that the wrenches fit the hose connections properly, that the paint is in satisfactory condition, and that the threaded portion of the hydrant wrench handle is lightly oiled.

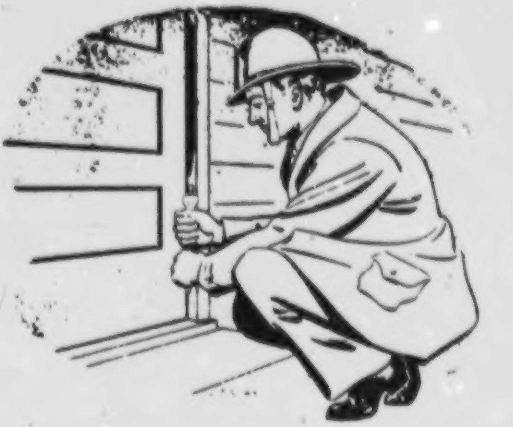

Figure 1-5. Spanner wrench handle as prying tool.

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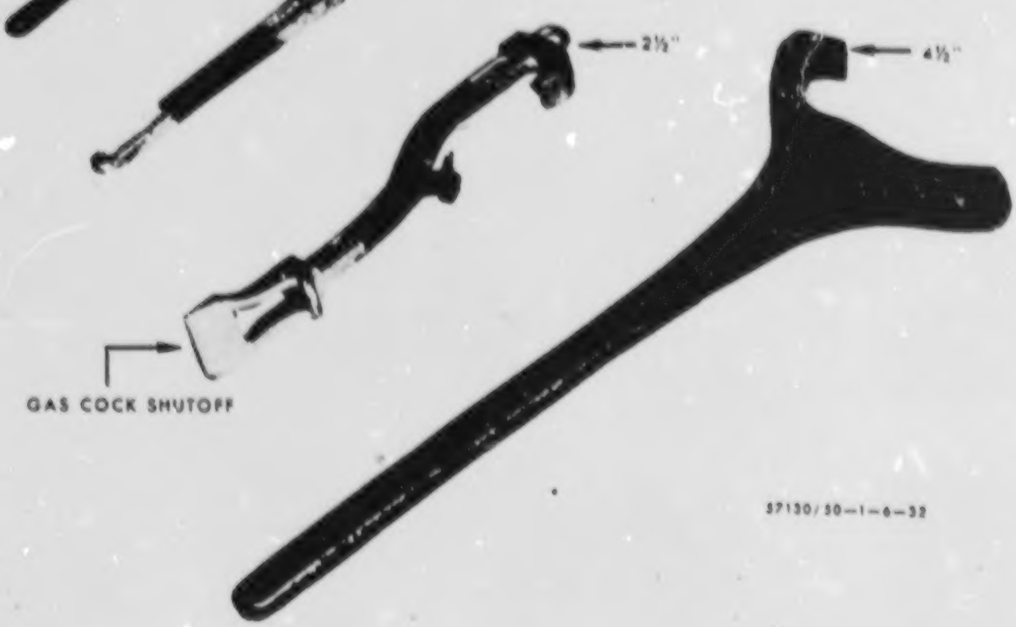
1"
1½"
2½"
4½"
GAS COCK SHUTOFF
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Figure 1-6. Spanner wrench types and sizes.

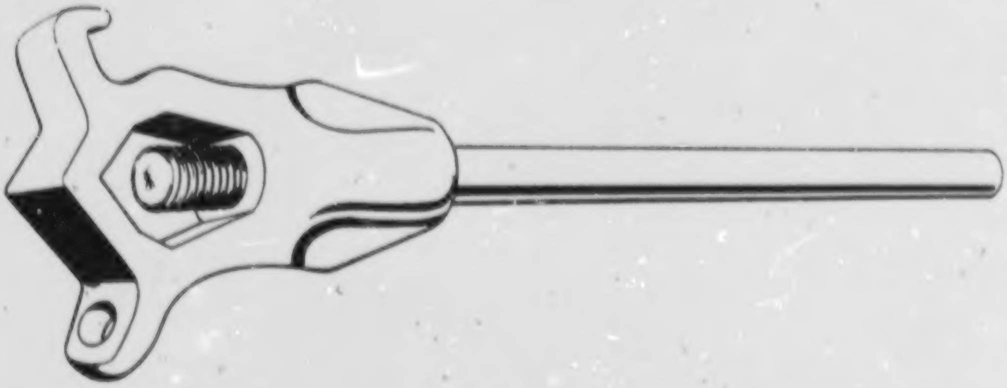

Figure 1-7. Hydrant wrench.

Hose Strap. You usually carry the hose strap, shown in figure 1-8, in a pocket of your firefighting clothing. These straps vary in size, but geneally consist of a 36-inch length of cloth strap with a handle on one end and a hook on the other. The hose strap is used for moving hose layouts, usually up ladders or staircases. After the hose is in the desired position, you can secure it to the ladder or staircase rail, as shown in figure 1-9. The cloth strap is usually the only part that wears out. It is very likely to receive cuts, torn threads, and wear and is sometimes attacked by mildew if you do not clean and dry it.

Rope Hose Tool. Normally, this tool is made locally. The pictures of the uses of the rope hose tool in figure 1-10 are better than words, but we should explain the maintenance required. The rope may be cut, scraped, start to unravel, or mildew. Check these points during your daily visual inspection. The failure of this tool during use could be very hazardous for you and your fellow firefighters. The hook point and the eye are subject to damage. During the daily visual inspection, check them for corrosion and the shape of the point, shank, and eye. The tool pictured is made of rope. Some of them are made of light chain.

Handtool Maintenance. We will describe handtool maintenance as it applies to two general categories—wooden-handled tools and edged tools. You will spend most of your tool maintenance time in these two areas.

Wooden-handled tools. The shoulder of the handle of a wooden-handled tool should be rather thick to prevent breaking, but the grip should be thin to give flexibility. All wooden-handles should be smooth and splinter-free. They should be sanded whenever a roughness develops. Wash the handles with soapy water, rinse, and dry them after each use. To prevent the handles from getting rough or warping, apply a coating of boiled linseed oil regularly. Each wooden handle with a metal tool attached should be checked regularly to make sure that there is a secure, firm, and snug fit between the two. Paint, varnish, or shellac on these handles will blister when it is subjected to heat. Painting also covers defects such as splinters, cracks, and rot. So remember, *don't paint wooden handles*.

Edged tools. Most metal tools are edged in some way. Some have sharp edges, like an axe. Others have shaped, nonsharp, precision edges, like a sledge hammer. Both edges need your care. You can

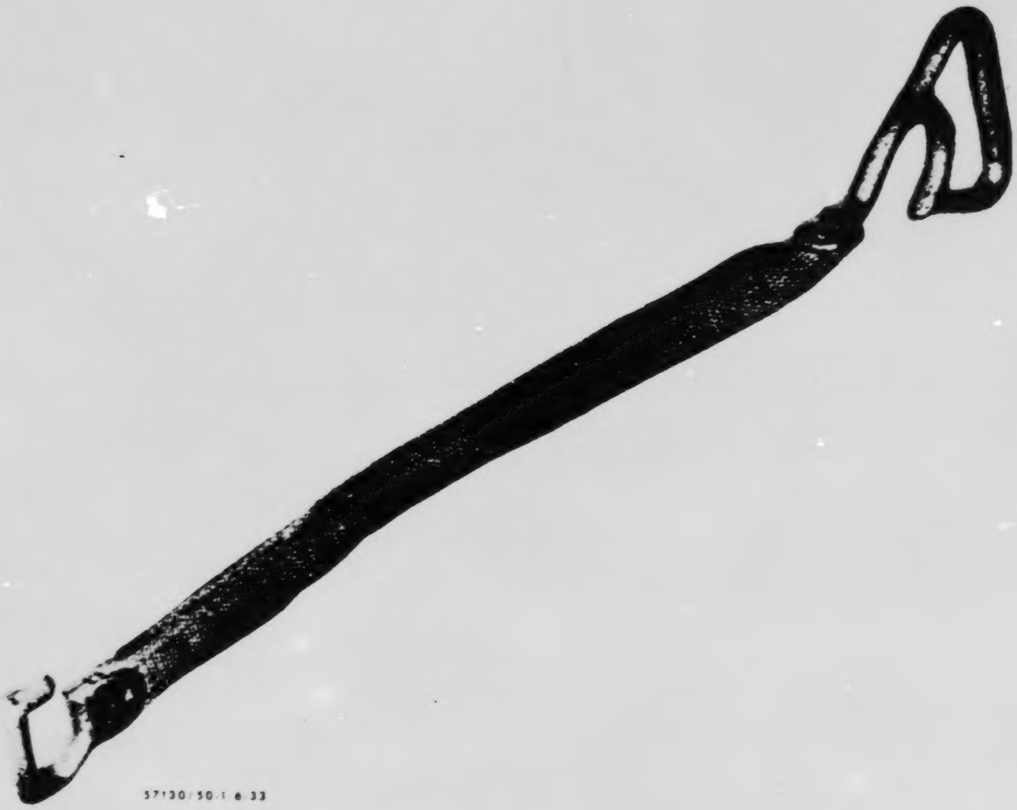

Figure 1–8. The hose strap.

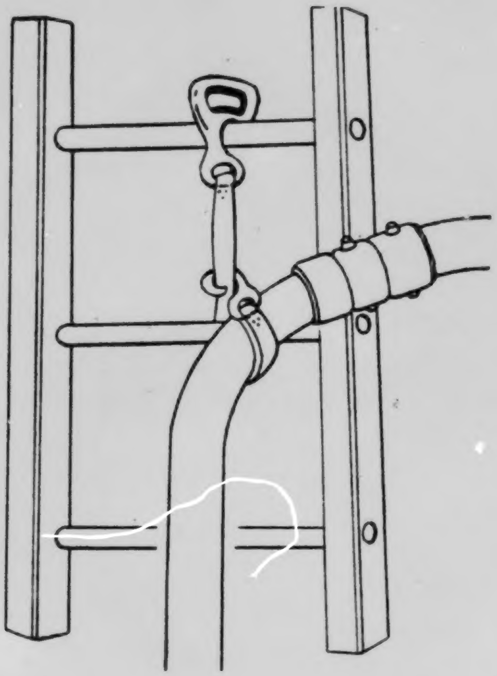

Figure 1–9. Using the hose strap.

destroy by using the tool improperly, by using it for a job it wasn't designed to do, or simply by plain carelessness in maintenance.

The fireman's axe is a good example of a sharp-edged handtool. If the blade is too sharp and the body of the blade is ground too thin, you can chip out pieces of the blade, dent it, or break it when you are cutting through gravel roofs or striking nails and other hard materials. If the body is too thick, regardless of its sharpness, it will be difficult to drive the blade through ordinary objects. The body thickness of the axe should be about ¼ inch at ¾ of an inch from the edge; ⅜ inch at 1¼ inches from the edge; and ½ inch at 2 inches from the edge. Take these measurements at the center of the blade. Its temper (hardness and toughness) should be such that the blade will not bend easily, yet not so hard that it breaks off when it strikes hard materials. If you overheat the metal when you are grinding the axe, the metal will soften. Grind the axe to preserve its body thickness as well as to sharpen the edge. After grinding, you should rub a stone over the edge to take off the keenness. Remember that a keen edge is not necessary and would soon be lost during its normal use. Do not paint any part of the axe blade. Painting may cover up metal fatigue or corrosion, can keep the blade from cutting fully, and cause it to stick. Remove rust spots with an emery cloth, and then lightly oil the whole blade.

Many of the other edged tools you are about to study need the same amount of detailed maintenance. If you are unable to perform the maintenance *properly*, send it to someone who can. *Don't do a bunged-up job!* Most of the tools you will use are not only sharp, but heavy, especially when dropped on your toes. It will always be important to you to keep safty in mind when you carry and use these tools. Make sure your grip is firm and you know exactly what you are about to do.

Exercises (A02):

1. The minimum opening of the universal thread adapter is________ , and the maximum opening is________ .
2. The steps in the maintenance of the universal thread adapter are to________ and ________.
3. To keep the inner lining of the hose jacket pliable, give it a periodic application of________.
4. To maintain the hose clamp, you must________, and________.
5. The handle of the spanner wrench serves two functions which are________ and ________.
6. On one end of a hose strap there is a ________, and on the other end there is a________ .
7. When you are inspecting a rope hose tool, look for________.
8. To prevent a wooden handle from getting rough or warped, apply________.
9. Do not paint any part of an axe blade because________ .

A03. Point out special characteristics of the ropes and knots used in fire protection.

Ropes. Ropes are indispensable in combating fires. The most widely used rope is the safety line, used for hoisting tools to various floors of a structure and for anchoring to stationary objects, ladders, charged hoselines, and other accessories. The safety lines for hoisting and anchoring used by the Air Force fire departments consist of 100-foot lengths of ¾-inch manila hemp rope with an eye splice in one end. For quick use, coil a safety line so that it will pay out without tangling, even when dropped from the top of a building.

For coiling a safety line, you normally use a frame containing two vertical posts about 14 inches high and 25 inches apart. Figure 1-11 shows you how this can be done. First wrap the rope several times horizontally around the upright posts; then wrap it vertically around the rope loop. When you reach the end of the rope, pull the horizontal pipe from the coil, and lift the coil from the vertical pipes. Fold the free end of the rope and slip it through the opposite end of

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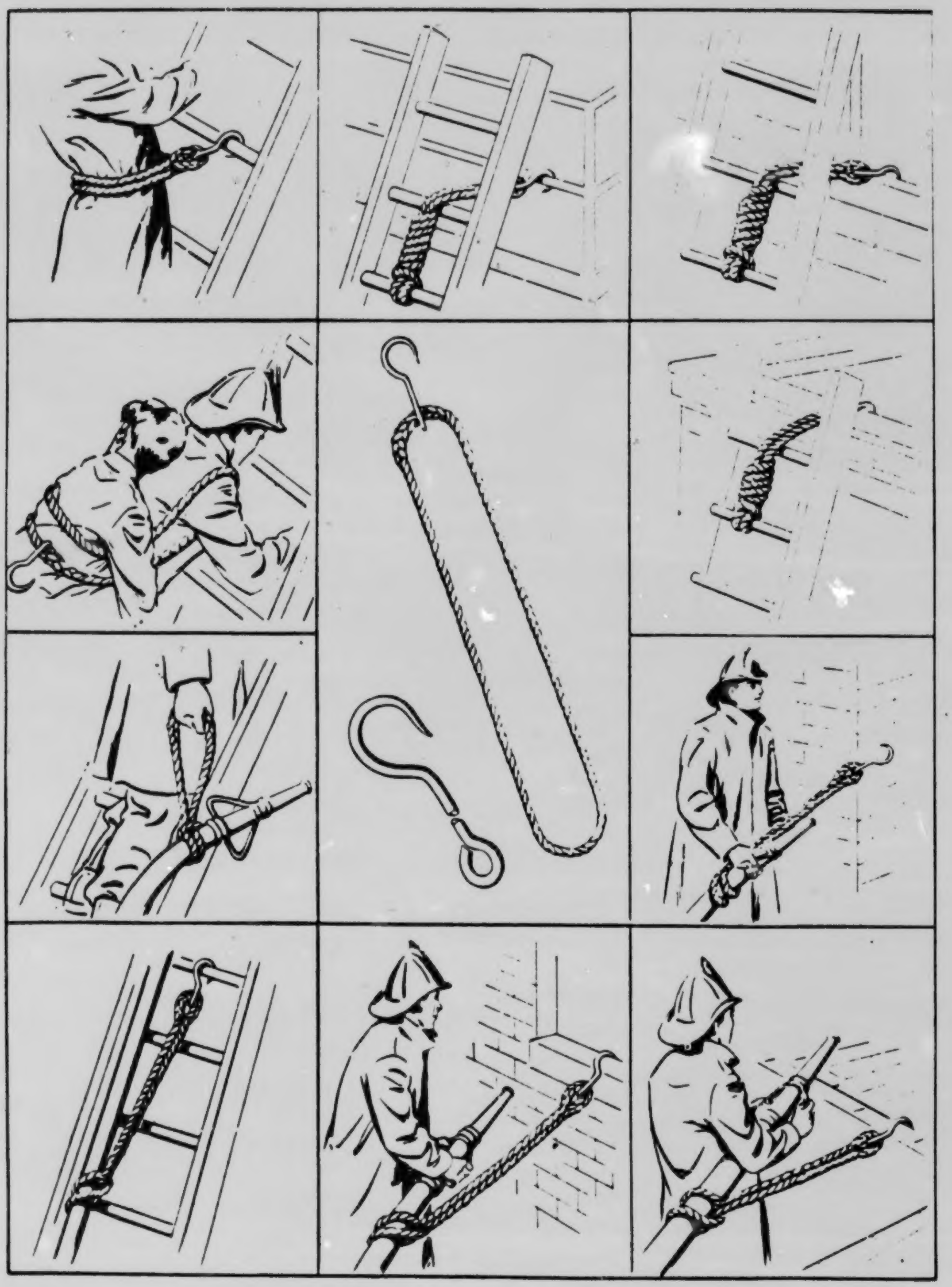

Figure 1–10. Use of the rope hose tool.

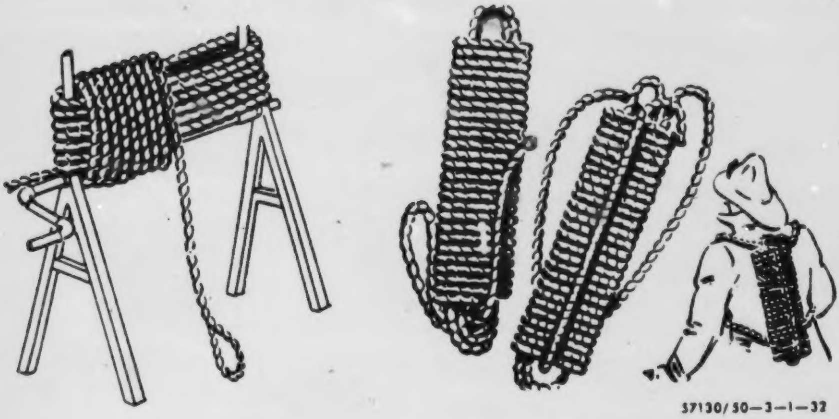

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Figure 1—11. Coiling a rope.

the coil and through the loop, pulling the loop tight. Make the loops large enough for the coil to be loaded over the shoulder.

Knots and Hitches. You should know the knots and hitches that hold securely but are easily tied and untied under all conditions. The rope ends should be whipped (tightly bound) to prevent fraying. Eyes may be spliced in one or both ends of the rope to expedite tying operations. The proper eye splice and the method of whipping a rope are shown in figure 1-12. Damaged rope should be replaced rather than spliced. The following terms are fundamental to a clear understanding of knot-tying, and you should study them until they are a part of your vocabulary.

- A bight is made when a rope is doubled back 180° and both sections are parallel.
- A loop is made by crossing the sides of the bight.
- A knot is a series of loops and bights forming a secure tie.
- A hitch is a loop and a bight, and is usually considered as a more temporary form of tie.

Half hitch. The half hitch is a safety measure used in conjunction with other knots and hitches. It is made by forming a loop around an object as shown in figure 1-13.

Clove hitch. This hitch is most frequently used in firefighting to secure a rope to another object quickly, especially to handtools. It is made by forming two half hitches in the same line (see fig. 1-14,A) with one half hitch next to the other, and then by placing the second half hitch on top of the first, as shown in figure 1-14,B. The clove hitch can be placed on an object, as you can see in figures 1-14,C, and 1-14,D.

Chimney hitch. The chimney hitch is used when it is necessary to anchor a rope to a solid object to strengthen the position of another object; for example, a charged hoseline on a ladder. An example of a chimney hitch is shown in figure 1-15. After the second loop is carried through, a half hitch is placed in front of the tie for safety.

Square knot. The square knot is used to join two ropes of equal diameter securely. You make it by holding one rope end in each hand; then placing the right end over the left and making a hitch. Then you place the left end over the right, again making a hitch.

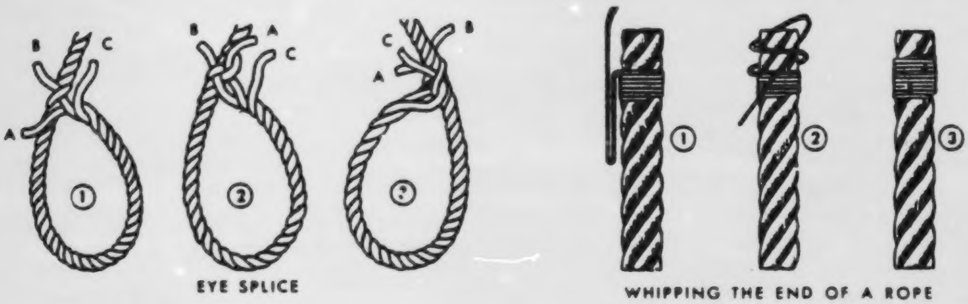
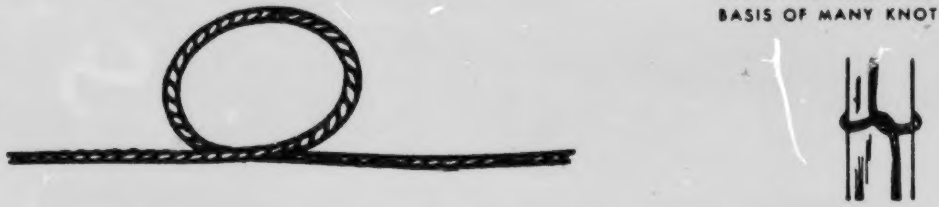


Figure 1—12. Splicing and whipping rope.



THE SINGLE HALF HITCH, THE BASIS OF MANY KNOTS.

Figure 1–13. Half hitch.

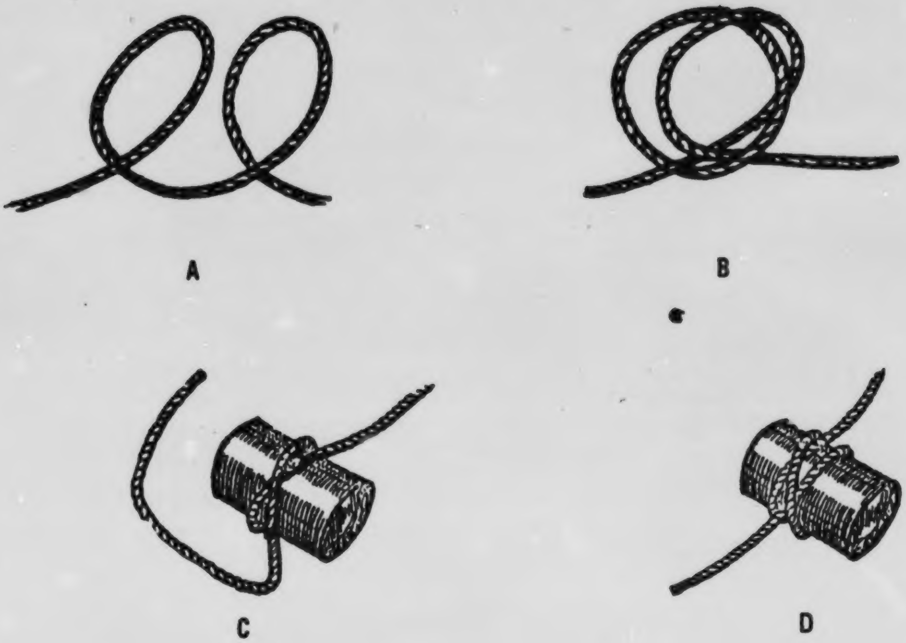
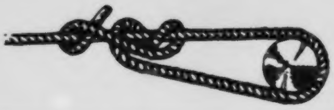


Figure 1–14. Clove hitch.



THE CHIMNEY HITCH USED FOR ANCHORING LINES. AFTER THE SECOND LOOP IS CARRIED THROUGH, A HALF HITCH IS PLACED IN FRONT OF THE TIE FOR SAFETY.

Figure 1–15. Chimney hitch.

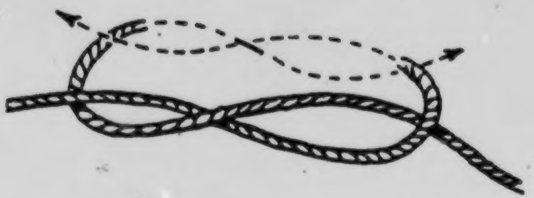


Figure 1–16. Square knot.

Complete the knot by pulling the ends, as shown in figure 1-16.

Becket bend. The becket bend is used to join two ropes of unequal diameter together. To tie this knot, make a loop in the end of one piece of rope. Pass the end of the other rope under and through the loop, around behind, and then over the loop and back under itself, as shown in figure 1-17.

Bowline. The bowline, shown in figure 1-18, may be used to form a secure loop in the end of a rope or for tying the rope securely around a beam, pole, or like object. Tie it by holding the rope in your left hand and the free end in your right hand. With your right

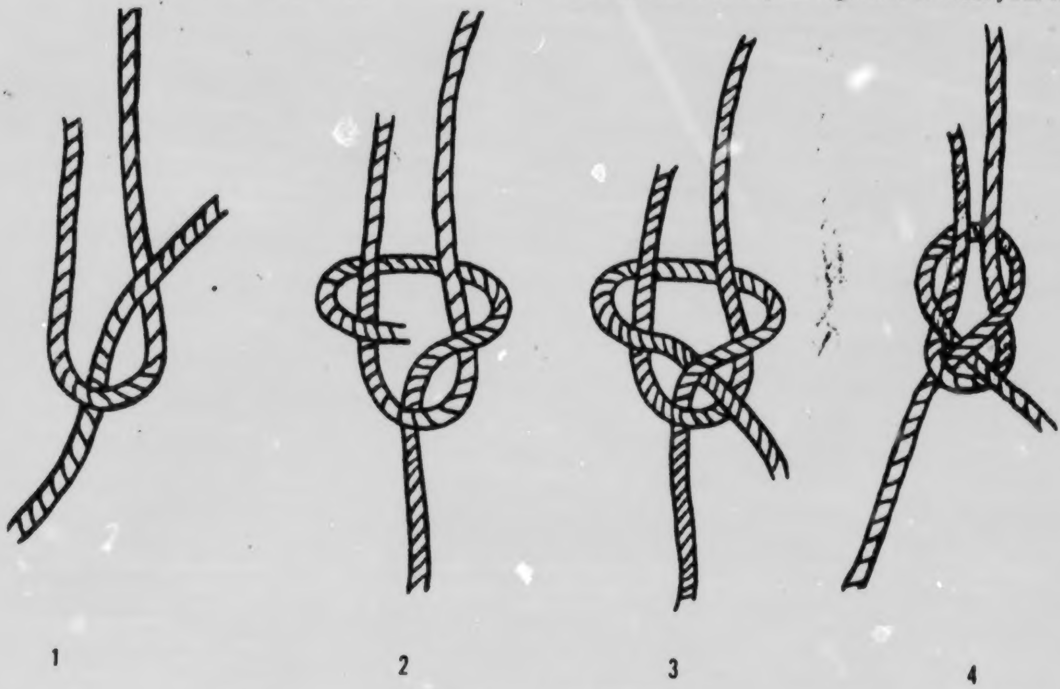


Figure 1–17. Becket bend.

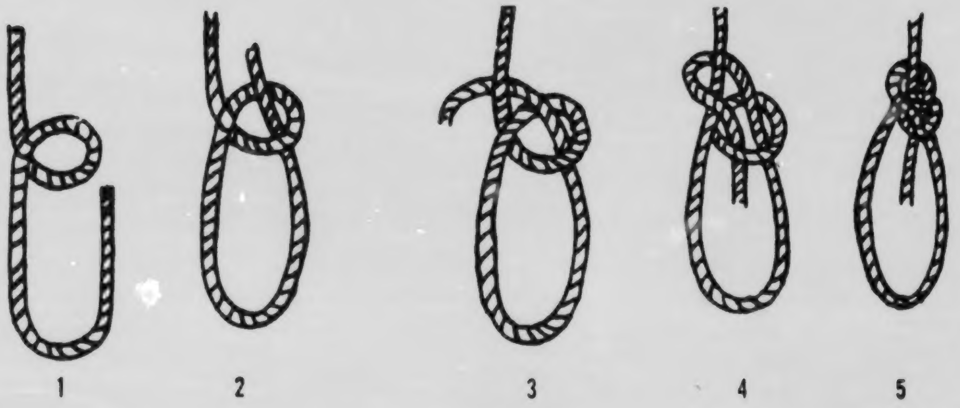


Figure 1–18. Bowline.

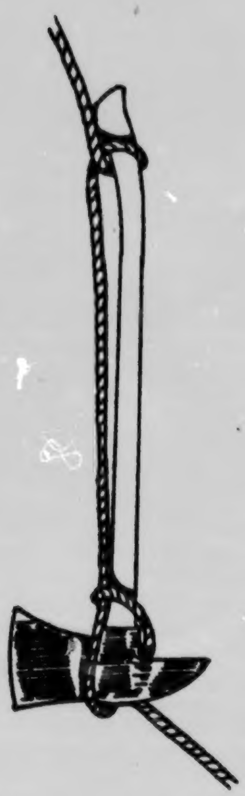


Figure 1–19. Ax hitch.

hand, make a loop in the rope near the left hand. Pass the free end under and through the loop around the standing line and back through the loop. Finish by tightening the knot. This is a convenient knot to use when you are hoisting a ladder. It is easily loosened, even when the rope is wet.

Ax hitch. Because of their shape and weight, axes are difficult to secure with rope. You must be careful to tie a secure hitch. Make the ax hitch by tying a half hitch around the ax handle at the head, passing the line under the head and back over the head and around the handle. Finish it with a half hitch around the heel of the handle, as shown in figure 1-19.

Pole hoist. The pole hoist is used in raising pike poles, pry bars, door openers, etc., to an upper story of a building. Tie a clove hitch about one end and one or two half hitches near the other end. The tools are usually raised with the heavy end first, as in figure 1-20.

Hose hoist. The hose hoist is used in raising empty or charged hoselines to an upper story of a building. Tie a clove hitch and a series of half hitches, as indicated in figure 1-21.

Extinguisher hoist. To hoist a fire extinguisher to an upper story of a building, place a clove hitch around the base of the extinguisher and make a half hitch around the collar. The bight should be opposite the extinguisher hose, as shown in figure 1-22. This prevents damage to the hose and fittings if the extinguisher hits the building or a projection while it is being hoisted.

Ladder hoist. One easy method of tying to a roof ladder is to run the rope under the first two rungs, over the next three, and tie it with a clove hitch, as in figure 1-23. Then form a half hitch and slip it over the opened hooks. Always hoist a ladder with the hooks toward the building.

Another method of tying a rope to a ladder is to tie a bowline in the end of the rope. Place the bowline between the 4th and 5th rung. Bring the bowline up to the top of the ladder and place it over the beams. Then with the standing part, form a half hitch over the hooks of a roof ladder.

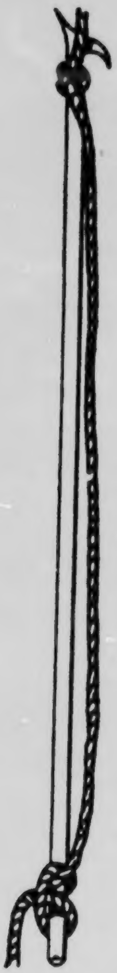


Figure 1–20. Pole hitch.

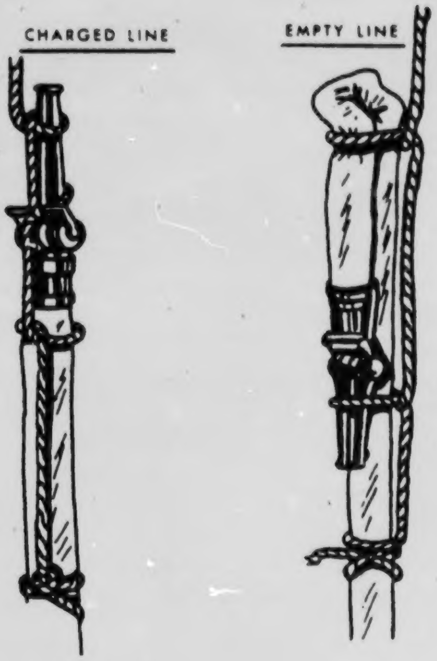


Figure 1–21. Hose hoist.

Exercises (A03):

1. What is the size and type of rope used in Air Force fire departments?

2. What does whipping the end of the rope mean?

3. What type of hitch is used in conjunction with other knots and hitches as a safety measure?

4. What knot is used to join two ropes of equal diameter?

5. When you are tying an extinguisher, tie a_________ at the base and tie a_________ at the top.

1-3. Ventilation

The act of ventilating a building is not an act of destroying property for destruction's sake. Some of the methods used in "the good old days" are no longer recognized. Your responsibility as a firefighter is to save lives and property; if you perform your duties in the way you were taught, you will be carrying out that responsibility. Ventilation, if properly done, should clear the building of smoke and gases, localize the fire, reduce smoke and forcible entry damage, and enable you to extinguish the fire with the least amount of water and in the shortest time. Ventilation will do all this if it is done *properly*. There are only two directions in which you can ventilate —vertically, as in figure 1-24; and horizontally, as in figure 1-25.

A04. Complete statements about opening various types of roofs.

There are many designs and shapes of roof styles and their names vary in each locality. Some of the more common styles are flat, gable, shed, hip, gambrel, lantern, butterfly, vault, dome, and mansard. The types of roofs discussed in ventilation practices are flat, pitched, and arched roofs. We will discuss separately the techniques of opening these three types of roofs, for each type presents a different opening procedure.

Flat Roof Opening Techniques. The best time for firefighters to determine the material from which roofs are constructed is in inspection surveys. The

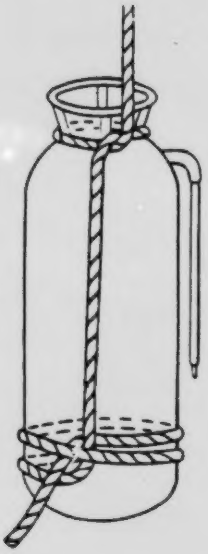


Figure 1–22. Extinguisher hoist.

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material used in flat-roof construction determines its ability to be cut with a fire axe. When he is cutting through a roof, the firefighter should make the opening rectangular or square to facilitate later repairs. One large opening is much better than several small ones. A procedure for opening a wood joist or rafter roof with an axe is given in the following sequence:

1. Use the following factors to determine the location for the opening to be made:
   - *a*. Location of intense fire.
   - *b*. Highest point on roof.
   - *c*. Direction of wind.
   - *d*. Existing exposures.
   - *e*. Extent of fire.
   - *f*. Obstructions.

2. Locate roof supports by sounding with the axe. It will sound hollow between the joists and the axe will bounce. Near or on top of a support, it will sound full and solid.

3. Mark off the location for the opening by scratching a line on the roof surface with the pick head.

4. Remove the built-up roof material or metal by precutting it and using the pick head to pull the material out of the way.

5. Cut the wood decking diagonally along the joist toward the hole. Cutting along a joist gives the blows a solid base to avoid bouncing.

Note: The joist should never be cut.

6. Use short strokes when chopping. If you must swing the axe high to apply more force, check for overhead obstructions and other firefighters. If the blade becomes wedged, be careful to avoid breaking the axe handle.

7. Pry up the roof boards with the pick end of the axe. After you have cut an opening in the roof, push the blunt end of a pike pole, plaster hook, or some other suitable tool through the roof opening to open the ceiling(s) below.

Power equipment for opening roofs is most useful and accelerates ventilation procedures. Power for this equipment may be provided by an electric generator or gasoline engines. Circular power saws can be equipped with a carbide blade. Chain and sabre power saws are also useful.

Pitched Roof Construction and Opening Techniques. The pitched roof is elevated in the center and forms a pitch to the edges. It is frequently found on single dwellings, barns, churches, supermarkets, and factories. In pitched roof construction, timber rafters or metal trusses run from the ridge to a wall plate on top of the outer wall at the eaves level. The raftes or trusses that carry the sloping roof can be of various materials. The sheathing boards are applied either squarely or diagonally across the rafters, and are usually applied solidly over the entire roof. Pitched roofs sometimes have a covering of roof-wood, metal, composition, asbestos, slate, or tile.

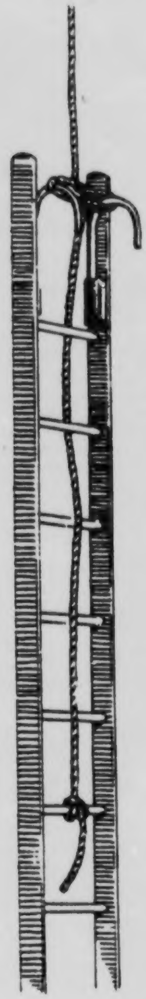

Figure 1-23. Ladder hitch.

The procedures for opening pitched roofs are quite similar to those for flat roofs except that additional precautions must be taken to keep from slipping. Suggested steps for opening pitched roofs are as follows:

1. Place a roof ladder on the roof and locate the position where the openings are to be made. Bounce the axe on the roof to sound for solid supports or rafters.

2. Move the roof ladder to either side of the selected location and use the ladder for support. The opening should usually be at the highest point of the roof.

3. Rip off the shingles or roofing felt sufficiently to make the initial cut. In some cases, it is best to first remove all shingles or roofing felt from the entire area where the hole is to be made.

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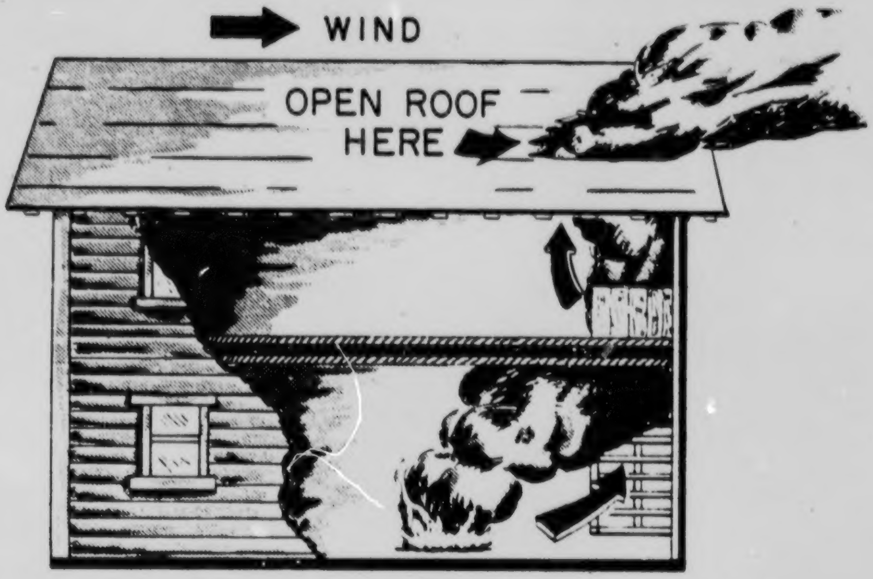
WIND
OPEN ROOF
HERE

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Figure 1–24. Vertical ventilation.

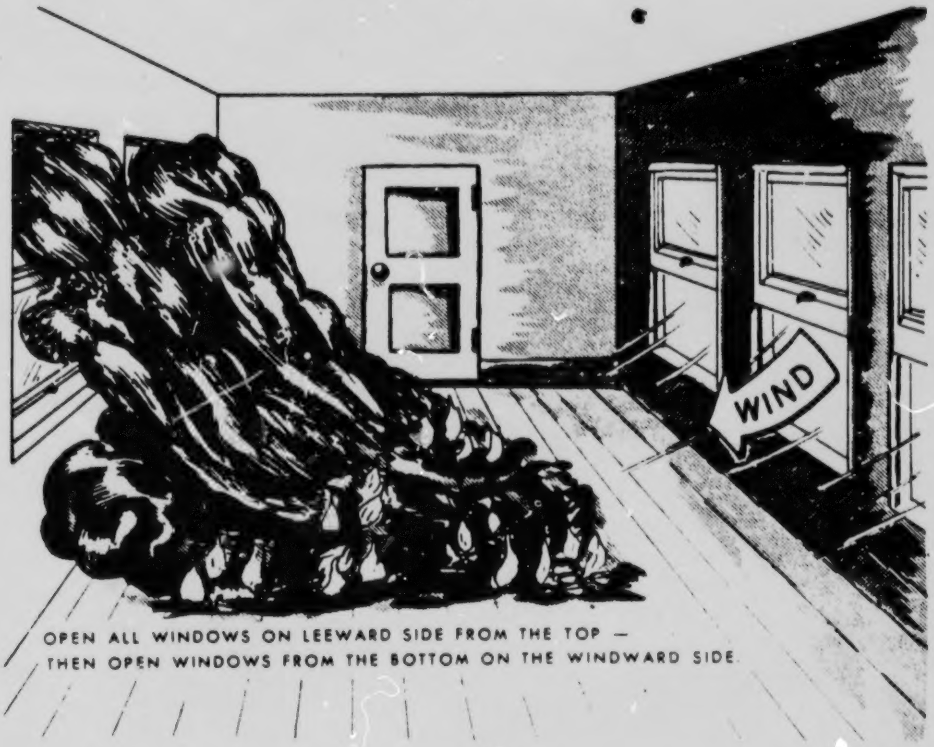
WIND
OPEN ALL WINDOWS ON LEEWARD SIDE FROM THE TOP —
THEN OPEN WINDOWS FROM THE BOTTOM ON THE WINDWARD SIDE.

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Figure 1–25. Cross (horizontal) ventilation.

4. Cut the sheathing along the side of a rafter the distance required for the opening. Cut the opposite side of the opening the same way. (The opening should be square or rectangular.)

5. Remove sheating boards with the pick axe or some other suitable tool.

6. Push the blunt end of a pike pole or other long handle tool through the hole to open the ceiling(s).

Arched Roof Opening Techniques. The cutting procedures for opening arched roofs are the same as for flat or pitched roofs except that using a roof ladder on an arched roof is doubtful. Long straight or extension ground ladders and aerial ladders are sometimes satisfactory if you place the ladder as flat on the roof as possible. Regardless of the method used to support the firefighter, the procedure is difficult and dangerous because of the curvature of the roof. Proper safety precautions should be observed.

Exercises (A04):

1. When you are locating roof supports, do this by_________ with an axe.

2. When cutting through a roof, make the cut diagonally along the _________ toward the hole.

3. When should you cut through a joist?

4. If you are opening a pitched roof, place a __________ on the roof to provide a sure footing.

5. To remove the sheathing boards after they have all been cut, use a _________ or some other suitable tool.

A05. Give selected facts about opening building components for ventilation.

Wood Floor Construction and Opening Techniques. Wood floors may be opened with a fire axe in much the same way as a flat roof. There are, however, two separate cutting jobs required because the finished floor and the subfloor usually run in different directions. The steps for opening wood floors with an axe are:

1. Determine the location for the hole, sound for floor joists, and cut one side of the finished floor with angle cuts.

2. Cut the other side of the finished floor in the same way and remove the flooring or floor covering with the pick of the axe.

Cut the subfloor using the same technique and angle cuts. It is usually advisable to cut all sides of the subfloor before removing the boards. If you remove just a few boards before you cut the others, heat and smoke may prohibit the completion of the job.

You can make neat cuts in wood floors with a power saw in the same way as you open a flat roof. Remove the tile, linoleum, or other such material from the floor before you cut it. Remove carpets and rugs or roll them to one side before you cut the floor. Power saws are most useful for cutting plywood sheathing.

Techniques of Opening Concrete Floors. If a concrete floor must be opened, the most feasible means is a compressed air operated jackhammer. But unless a jackhammer is readily available, this process is extremely slow. It may not prove beneficial for fire extinguishment but it may be the best means for rescue operations. Concrete cutting blades are available for most portable power saws. There are also special purpose nozzles designed to penetrate masonry and some types of concrete. These devices are primarily nozzles with provision for a 1-½-inch hose line to be attached to the nozzle which supplies the water under pressure. It is best to strike the masonry or concrete first with a sledge hammer to shatter the concrete topping and provide a center for the tool.

Opening Techniques for Masonry and Masonry-Veneered Walls. Masonry exterior walls are usually 8 or 12 inches thick, depending upon the particular materials used and size of the building. The supporting members of masonry-veneered walls are wood with one layer of brick or stone on the exterior to give the appearance of a solid brick or stone wall. The upright wood supporting members are called "studs." These studs are usually 2 inches by 4 inches, spaced at approximately 16-inch intervals. The presence of these studs creates a hollow space in the wall through which fire can spread.

The opening of masonry walls is often referred to as "breaching." Here again, various power tools prove to be the most worthwhile and faster, and they usually require only one man to operate them. Firefighters should be sure that charged lines are in position before breaching a wall at a fire.

Opening Techniques for Metal Walls. Metal is being used quite extensively for exterior walls in modern construction. Plastic is also being used to some degree in a similar way. Construction of this type can be found in storage buildings, service stations, store fronts, and other commercial structures. The metal for these walls is usually in the form of sheets, sections, or panels. The metal sheets are fastened to wood or metal studs by bolts, screws, rivets, or welding. The metal may have a painted or porcelain coated surface, and a damaged panel is usually difficult to replace. ENTERING THROUGH A DOOR OR WINDOW IS USUALLY PREFERRED TO OPENING A METAL WALL AND ITS BREACHING IS USUALLY CONSIDERED AS A "LAST RESORT." If opening a metal wall cannot be avoided, a metal cutting power saw is normally the best way to open it. It is extremely important that electrical wiring or plumbing is not cut. Cut the metal along the studding to provide stability for the saw and ease of repair. You can usually cut the insulation or other material in the wall with an axe for removal. Examine the inside wall surface, if any, for the best method for its removal.

CAUTION: Take proper precaution when you are opening metal walls covered with porcelain, because there may be flying porcelain chips.

Opening Techniques for Wooden Frame Walls. Wood frame walls are constructed with wood or fiberboard sheathing nailed over studs. The exterior siding is fastened over the sheathing. The framework between the studs is either hollow or filled with insulation material. The inside of a wooden frame wall is finished with gypsum board, plaster over metal, wood, or gypsum lath. It is not always necessary to open a wooden frame wall completely.

CAUTION: It is extremely important to watch for electrical wiring and pipes in the wall.

The techniques for opening wooden frame walls are the same as we have discussed for roofs and floors except that the opening is vertical instead of horizontal. First remove the siding, sound the wall for stud supports, and cut the sheathing along a stud to the desired size of the opening.

Opening Techniques for Partitions. Solid masonry partitions should be opened in the same manner as has been described for exterior masonry walls, and the same precautions should be taken. Unless previous inspections have been conducted on the building, it is very difficult to determine the construction of a partition during firefighting procedures. If you need to make an opening in a partition, follow these procedures:

1. Select the location of the opening and, before attempting to open the partition, check the partition for electric wall plugs and switches.
2. Have sufficient tools such as power tools, picks, fire axes, sledges, and pry bars, available.
3. If the studding in the partition is wood or metal, locate the studs by sounding.
4. Cut along the studs with a fire axe.
5. If the partition is hollow clay tile or gypsum blocks, crush one or two blocks with a sledge or jackhammer, and you can remove the other blocks or tile more easily.

Opening Techniques for Ceilings. Ceilings consist of built-up materials applied to the underside of the floor joist, concrete floor, or ceiling joist. This built-up material may be lath and plaster, ceiling tile applied to furring strips, sheet metal, or gypsum wall board. A dropped ceiling consists of furring strips that are hung the desired height from the roof or from the floor above, to which a ceiling material is fastened. To open a plastered ceiling, the firefighter must first break the plaster and then pull off the lath. A pike pole is often used for this operation. Metal and composition ceilings may be pulled from the joist in the same way. When you are pulling, do not stand under the space to be opened. Pull down and away to keep the ceiling material from dropping on your head. Never attempt to pull down a ceiling without wearing a helmet, gloves, and eye protection. Always stand between your work and an opening through which you can retreat if necessary.

Exercises (A05):

1. When you are removing a floor, why should you wait until all the floor boards are cut before you remove them?

2. What is the most feasible way to open a concrete floor?

3. Before you open a masonry wall, what should be in position?

4. What technique is preferred to breaching a metal wall?

5. What must you look for in wooden frame walls before you cut them?

6. When is the best time to determine the construction of a partition?

7. Describe your protective gear when you are pulling down a ceiling.

A06. Complete statements about the directional ventilation of buildings.

Vertical Ventilation. To establish vertical ventilation, you must work from the top down. Heated gases and smoke rise to the highest point available, and the roof is the highest point, whether it is flat or peaked. Follow the important steps in the procedure for ventilating a roof for your own safety and for the accomplishment of a thorough job of ventilation.

a. Check the condition of the roof supports to make sure that they have not been burned away or weakened to a point where they may collapse under your weight. Feeling the roof for hotspots helps you determine if the fire has reached that point to cause weakening.

b. Plan a way of escape from the roof in case of an emergency, such as roof collapse. You should have on a lifeline, especially on a peaked roof, to prevent falling.

c. Use any available openings that are part of the roof construction, such as skylights or roof trapdoors.

d. Make certain the passageway for the smoke and heat extends down through the ceiling of the room. A hole in the roof is of no use if there is no relief for gases, heat, and smoke in the room below.

e. The openings should be large enough to provide a rapid exit for the smoke and gases.

f. Work with the wind at your back, keeping in mind the heat, explosive characteristics, and toxic effects of escaping gas.

Cross, or Horizontal, Ventilation. If the smoke and gases have not reached the higher levels, cross ventilation can clear the building one floor at a time. Windows are the easiest and generally most available for the common types of buildings, but the indiscriminate opening of windows and doors can defeat the purpose of ventilation.

a. Open the windows on the leeward side first; then open the windows on the windward side. Open the upper half on the leeward side and the lower half on the windward side. If you cannot open windows, break the upper half of the windows on the leeward side and the lower half on the windward side. Remember to stand at one side when you break a window.

b. After one floor is clear, ventilate the next floor in the same way.

c. It at all possible, avoid making openings below the level of the fire.

d. If the opening is made at the same floor level as the fire, hoselines should be available for immediate use.

e. Avoid ventilating a building in such a way that you let the fire be drawn through any building part that is not involved.

f. When you make an opening, exercise great care to prevent the spread of the fire to exposures, and have hoselines available to protect the exposures.

Entering. Before entering a building, the senior officer in charge should find out whether the conditions in the building are safe for personnel. When the draft caused by ventilating reduces the volume of smoke so that visibility is improved, it usually means that the building is ready for entry. After the exposures have been done, and rescue efforts have been satisfied, the next step is to reach the fire and extinguish it. Other openings are made, as necessary, as near the fire as possible. See figure 1-26 for right and wrong ventilating procedures.

If you have no breathing apparatus available, the next best method of moving through smoke-filled areas to locate the base of the fire is to advance behind a water-fog curtain, keeping as close to the floor or ground as possible in order to allow the hot gases and smoke to pass over you. Use a water-fog curtain only for your personal protection when you encounter difficulty in breathing or irritation of the eyes or when the heat is too great for safety. The water fog tends to drive the smoke away, to absorb it, and to cool the heated atmosphere; but it also causes water damage. Therefore, use your breathing apparatus whenever possible in any smoke-filled area: it gives you maximum protection, permits you to advance using less water, and thus eliminates unnecessary water damage. Take the same precautions during extinguishment as you take for ventilation and rescue.

It may not be necessary to ventilate a building to locate a fire. It is also inadvisable sometimes to wait until rescue work is completed. Actually, these two operations, rescue and ventilation, go hand in hand. When there are enough people available, these operations can be assigned to certain personnel and coordinated by the senior officer in charge. By coordinating ventilation, rescue, and advancing the lines, the operation will proceed in the safest way possible by eliminating or reducing the danger of a back draft or increase in fire spread. These dangerous possibilities are always present when several groups are working without each group knowing what the other groups are doing.

Exercises (A06):

1. Check the condition of the roof supports before going on the roof because ________ .
2. When working on the roof, you should work with the wind at ________ .
3. You should open the windows on the ________ side first, then open windows on the ________ side.

6-08

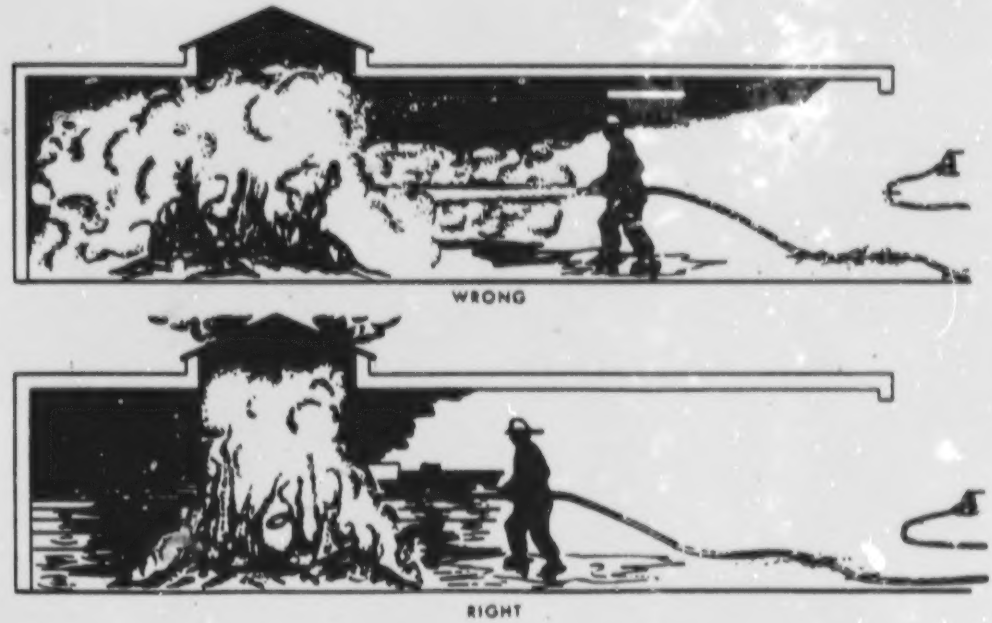

Figure 1–26. Open for ventilation before entering.

4. Always have a ________ available for immediate use when you are starting horizontal ventilation.
5. You will know when a smoke filled building is ready for entry when ________ .

A07. Point out the way to handle forced ventilation and its value.

The prefire plans that you studied or helped to make can eliminate most of the guesswork in ventilation. But basement or cellar fires ar sometimes extremely hard to ventilate because of the difficulty in creating a controlled draft. In such situations, a blower-type fan is used to eject the smoke. This piece of equipment is becoming more important in the Air Force fire service.

Forced Ventilation Equipment. It is difficult to classify forced ventilation equipment by any particular type. The principle applied is that of moving large quantities of air and smoke. All these portable blowers are powered by electric motors or gasoline engines. Portable ejectors and several methods of using them to ventilate are shown in figure 1-27. Electric forced air blowers are identified by different names, such as ejectors, extractors, exhausters, and blowers. Forced air blowers should always be equipped with explosion-proof motors and power cable connections for use in a flammable atmosphere. Forced air blowers should be shut down when they are moved. Before they are started, be sure that no one is near the blades and that clothing, curtains, or draperies cannot be drawn into the fan. Always move blowers by the handles.

Some Advantages of Forced Ventilation. The value of mechanical or forced ventilation is realized when, in order to protect human life, you must rid areas of an undesirable atmosphere. Even though fire may not be a factor, a contaminated atmosphere must be rapidly and thoroughly ejected. Forced ventilation, though it is not the only means of clearing a contaminated atmosphere, is always a welcome addition to normal ventilation. Some of the reasons for employing mechanical or forced ventilation are given in the following list:

1. Insures more positive control.
2. Supplements natural ventilation.
3. Speeds the removal of contaminants, facilitating more rapid rescue under safer conditions.
4. Can be used where other methods fail.
5. Reduces smoke damage.
6. Promotes good public relations.

Exercises (A07):

1. Always move a forced air blower by ________ .

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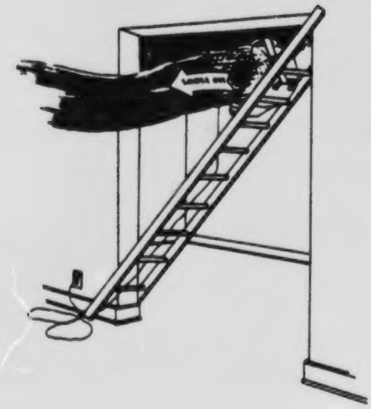
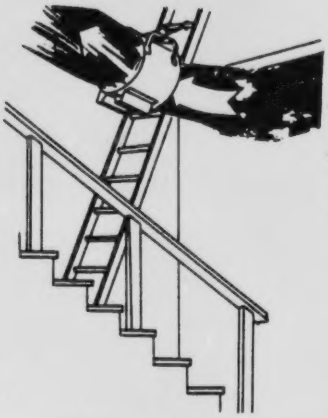
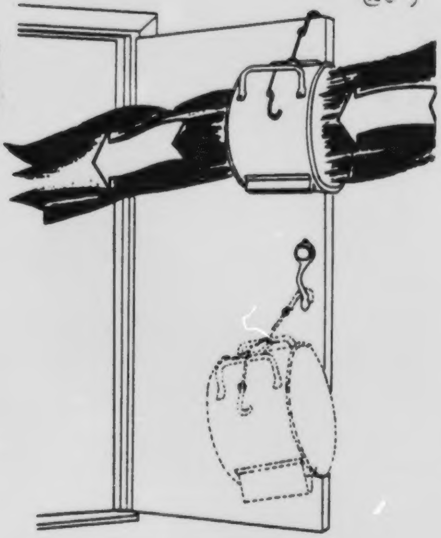


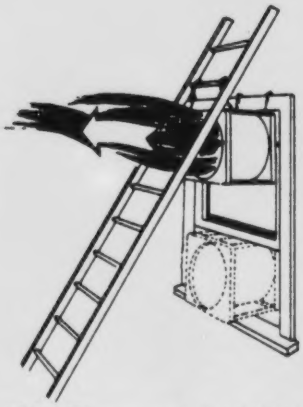
Hall or Archway Placement



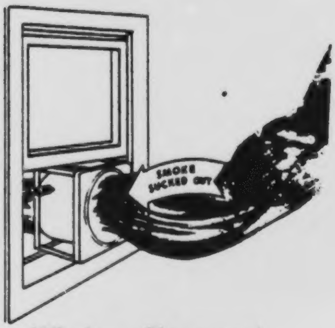
Stairwell Installation



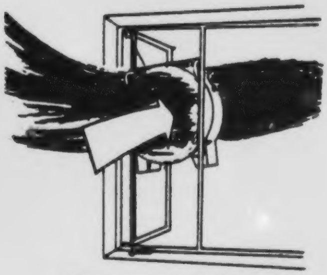
Door Placement



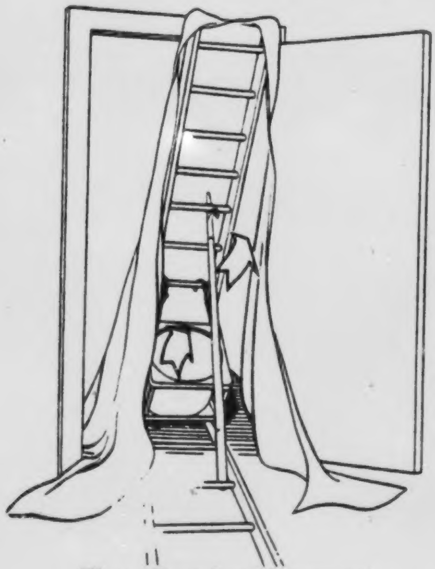
Ladder Placement for Window



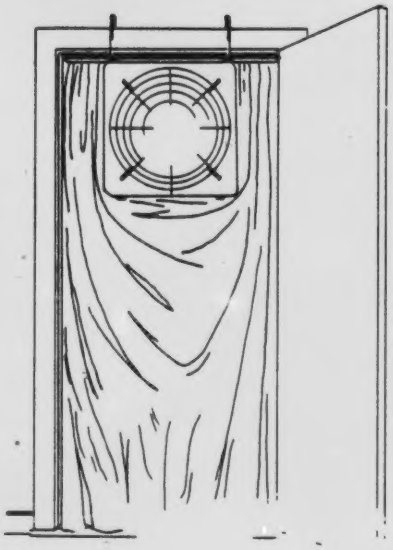
Window Placement



Casement Windows



Floor Opening Placement



DOOR CASING PLACEMENT

Figure 1–27. Use of portable smoke ejectors.

6IC

2. When you move a forced air blower, the motor must be_________.

3. When you start the blower, make sure that no one is_________.

4. When is the value of a mechanical blower fully realized?

CHAPTER 2

Hose Operations

THERE ARE MANY different types of fire hose but the types that we will discuss are variations of the cotton-jacketed, the polyester-jacketed, and the unlined linen hose. All hose is used in sections fitted with a male threaded fitting at one end and a female threaded fitting at the other. The length of the section may range from 10 to 150 feet.

2-1. Hose

Four types of hose are used in the Air Force. Some are used to a much greater extent than others. These four types of hose are discussed in the following paragraphs.

A08. Specify the use of selected types of hose.

Polyester-Fiber-Jacketed Hose. Polyester-fiber-jacketed hose in 2½- and 1½-inch sizes is lined with rubber. The 4½-inch, soft suction hoses are also constructed in this way. Polyester-fiber-jacketed, rubber-lined hose consists of a single-seamless, circular-woven, polyester-fiber jacket with a 3- or 4-ply, lap-jointed synthetic-rubber liner, made entirely from synthetic materials. These materials are subject to mechanical injury the same as rubber- or cotton-jacketed fire hose but have several advantages. They are resistant to oil, grease, many chemicals, and some acids. While they are still wet, they can be replaced on the truck without drying, since the synthetic materials are not affected by mildew. Of course, you should always clean any dirt, mud, etc., from this hose, as from any other type.

Cotton-Jacketed, Rubber-Lined Hose. Cotton-jacketed, rubber-lined hose has a single, double, or triple-woven cotton jacket with a 3- (or more) ply, lap-jointed, inner rubber liner. The inner surface of the rubber liner is smooth, to reduce friction loss and increase the pressure and volume of water delivered at the nozzle. The rubber liner and the cotton jacket are bonded by a vulcanizing process that produces a firm bond and added strength. This type of hose is manufactured in 1½- and 2½-inch sizes and also in the large diameters (4½ inches) used for soft-suction hoses to connect fire pumpers to hydrants.

Rubber-Covered and Wire-Reinforced Hose. Rubber-covered, rubber-lined hose is made of plies of cotton fabric covered internally and externally with layers of rubber. This hose is less flexible than the cotton-jacket hose but can withstand higher pressure. When reinforced with spirally wound wire molded into the rubber and fabric, it can withstand even higher pressure and suction without bursting or collapsing. Wire-reinforced hose is used principally for hard suction hose. Rubber-covered, rubber-lined hose is supplied in sizes ranging from the ¾-inch to the large 4½-inch size, which is used for pump intake lines.

Unlined Linen Hose. Unlined linen hose consists of one or two jackets of woven linen without rubber lining or cover. It is manufactured in the 1½-inch or 2½-inch sizes, for use on standpipe systems. Linen hose is not used where protection from water damage is required.

Exercises (A08):

1. What hoses are used for 4½" soft suction hose?

2. What hoses are used for 4½" hard suction hose?

3. Where is unlined linen hose used?

2-2. Couplings

Hoselines may be made any desired length by coupling individual sections together. Hose couplings are designed to allow rapid assembly and disassembly of hose lines.

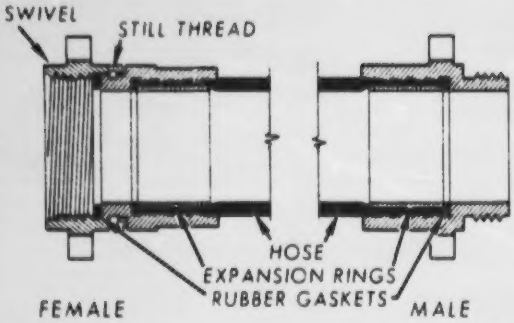


Figure 2–1. Fire hose couplings.

A09. Give important features of selected couplings and nozzles.

Male and female hose couplings are shown in figure 2-1. The hose is fastened inside one end (called the bowl, or tailpiece) of a coupling by an expansion ring placed inside the hose and expanded to lock the hose against the coupling. Male couplings consist of a single piece of brass or some other malleable metal threaded on one end. A special expansion gasket between the hose and the coupling insures a watertight joint. Female couplings consist of a tailpiece and an inside threaded metal swivel. The swivel is fastened to the coupling by the special interlocking retainer (called a *still* thread) that allows the swivel to turn freely on the tailpiece. A gasket between the swivel and the tailpiece prevents water leaks. A projecting pin, a socket, or guard lugs on the coupling make it easier to tighten and loosen the connections.

Double Male Couplings. A double male coupling is a single piece of metal hose coupling containing two sets of exposed threads, as shown in figure 2-2. The purpose of the double male connection is to join two female hose connections.

Double Female Couplings. These couplings consist of two, or sometimes three, pieces of metal hose coupling containing two sets of female threads, figure 2-3. When double female couplings have only one swivel, the connection frequently contains only two pieces of metal, and the solid (no swivel) portion should be connected first. Double female couplings with two swivels have three metal parts, and the swivel to be connected first is optional. The purpose of the double female connection is to join two male couplings to complete a hose layout.

Reducing Couplings. These couplings, shown in figure 2-4, are used to connect two different-sized hoses or appliances. The most common reducer contains a 2½-inch female connection. With it you can attach a 1½-inch hose to a 2½-inch hose — a connection that may be needed for increasing pressure or

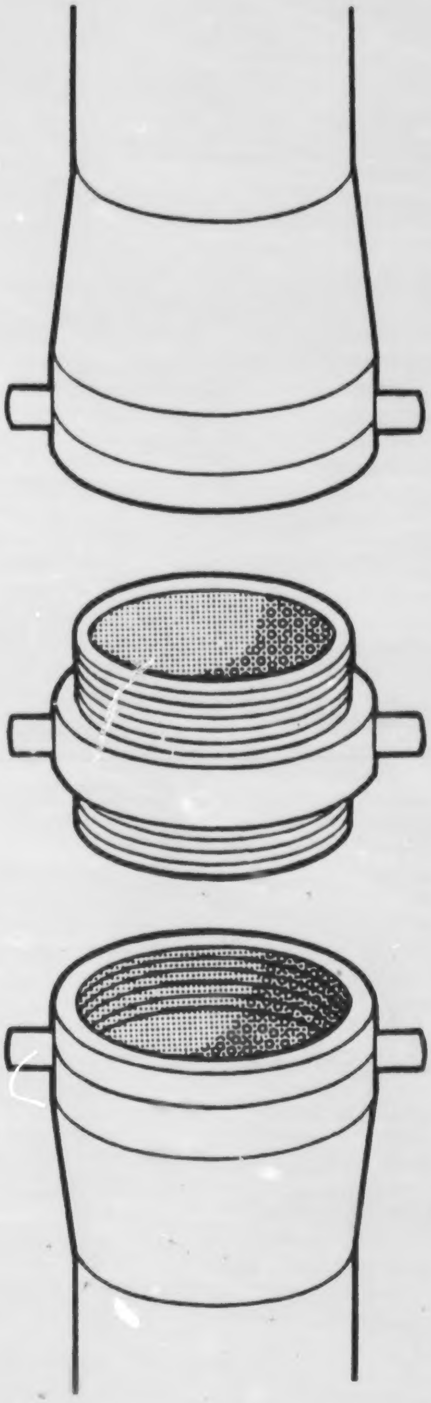


Figure 2–2. Double male coupling.

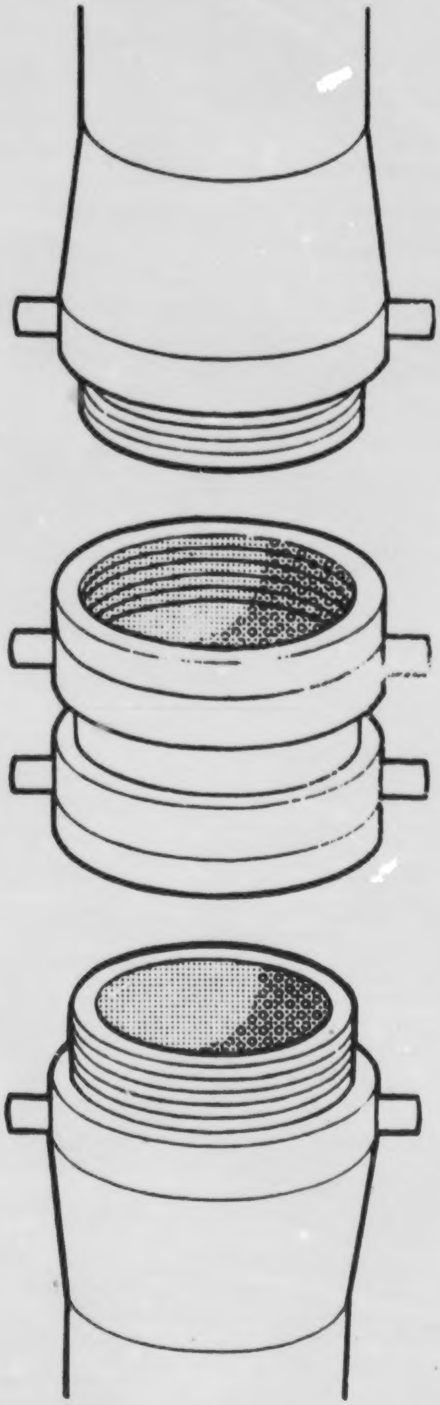


Figure 2–3. Double female coupling.

moving a lighter hose into a crowded area or a location where access is difficult.

Siamese Connections. This fitting has three sets of threads and is shaped like a Y, as shown in figure 2-5. It has two sets of female threads and one male thread. Its primary purpose is to connect two 2½-inch intake lines into a single 2½-inch outlet line or into another heavy stream appliance.

Wye Connections. A plain wye connection or a gated wye connection is similar in shape to a Siamese connection except that it has two male-threaded connections and one female-threaded connection, as in figure 2-6. The use of the wye is normally the opposite from that of the Siamese. The purpose of the wye is to divide one strong stream into two less-powerful streams. The gated wye is commonly used to extend one 2½-inch line into two 1½-inch lines and either outlet can be closed by a "gate," or ball valve.

Nozzles. The term "nozzle" (as applied to fire department work) refers to a metal tube in some form that is attached to the end of the hose to direct and shape the fire stream and to give the fire stream added velocity and direction. In order to have a good stream, you must have a well-shaped nozzle. The stream begins to take shape at the point where the nozzle is attached, but most of the shape of the stream is created at and near the nozzle tip. The resistance offered in the hose (friction loss) causes the water to churn, and the water will maintain that condition unless corrected by the smooth bore and taper of the nozzle tip.

The "playpipe" nozzle with a shutoff valve is one of the most commonly used nozzles. It has three separate parts: the playpipe, the shutoff valve, and the tip, as shown in figure 2-7. But the "fog" nozzle is fast becoming one of the common types of structural firefighting nozzles. One type of fog nozzle is adjustable. It can produce a stream pattern from straight stream to full fog. This nozzle is very useful and has a much wider range of uses than the solid-stream nozzle. One of the desirable features of a fog

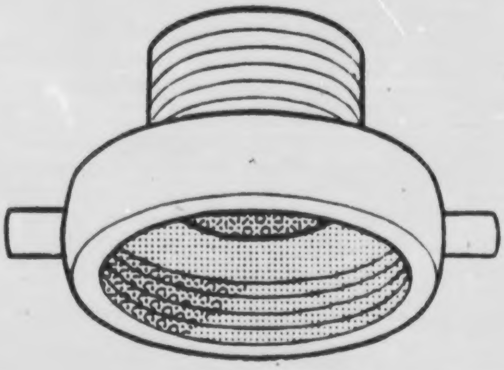


Figure 2–4. Reducing coupling.

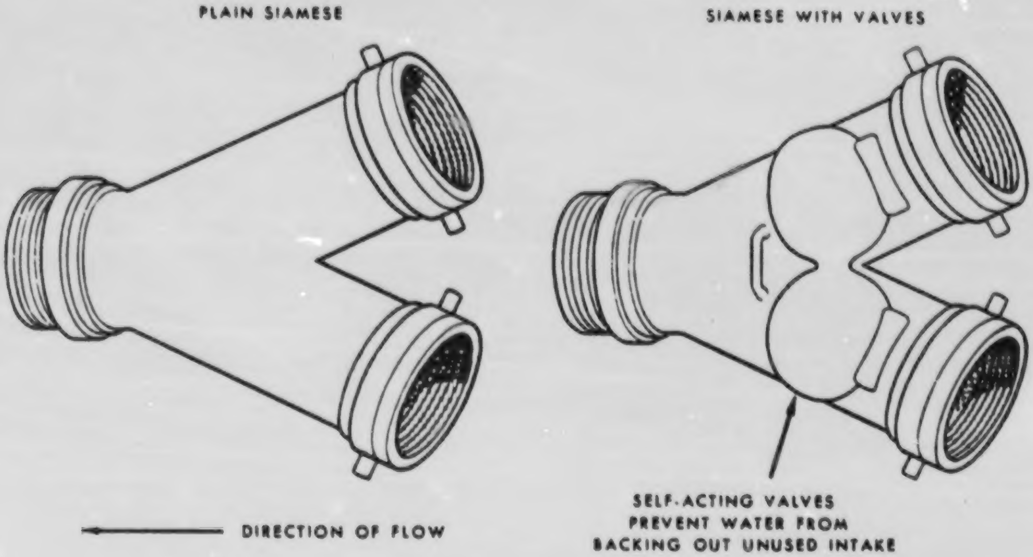

PLAIN SIAMESE
SIAMESE WITH VALVES
DIRECTION OF FLOW
SELF-ACTING VALVES
PREVENT WATER FROM
BACKING OUT UNUSED INTAKE

Figure 2–5. Siamese connections.

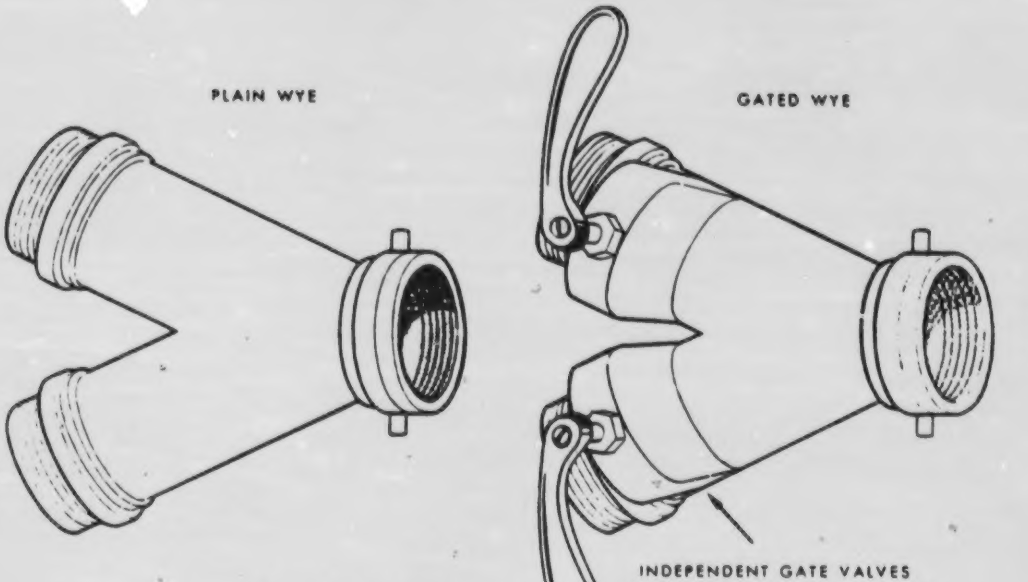

PLAIN WYE
GATED WYE
DIRECTION OF FLOW
INDEPENDENT GATE VALVES
ON DISCHARGE CONNECTIONS

Figure 2–6. Wye connections.

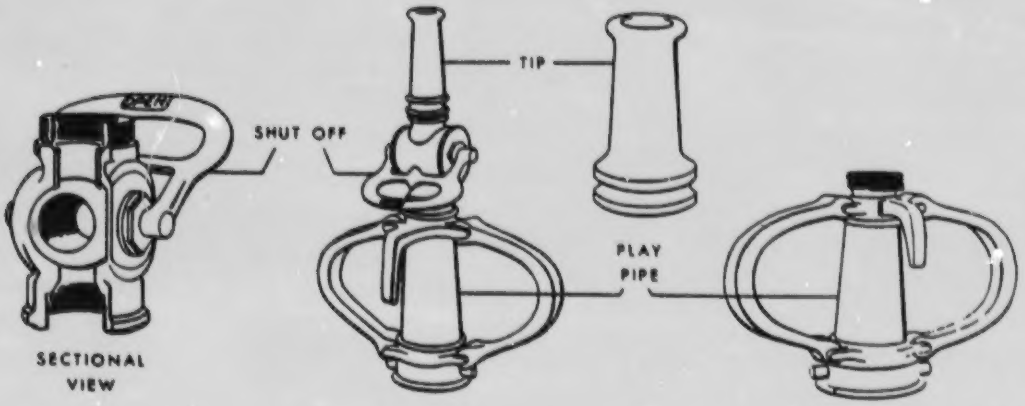


Figure 2-7. Playpipe nozzle.

pattern is its great ability to absorb heat rapidly. In addition, the amount of water damage is usually reduced when this type of nozzle is used.

Exercises (A09):

1. What is the purpose of the double male connection?
2. If the double female coupling has only one swivel, which end is connected to the hose first?
3. If the connection has two sets of female threads and one set of male threads, what is it called?
4. If the connection has one set of female threads and two sets of male threads, what is it called?
5. Name the parts of the playpipe (straight bore) nozzle.
6. State the desirable features of a fog nozzle.

2-3. Hose Layouts and Handling

The methods of loading hose on the pumper are directly controlled and influenced by the hose layouts and hose advancement to fires. Though time is not so important when you are loading hose, it is a definite and important factor in hose layouts, which require the utmost in skill and cooperation. Only two hose layouts are used in the Air Force: the straight lay and the reverse lay. Local opinion, usually influenced by local conditions, determines the most practical layouts to use.

A10. Explain certain steps in the two types of hose layout.

Straight Lay. Laying the hose from the hydrant to the fire is called the *straight* lay and is shown in part 1 of figure 2-8. This lay is sometimes the only lay used where hydrant water pressure is adequate to supply good fire streams. In some cases, this lay is used as a feeder line to a pumper, which in turn supplies one or more 1½-inch lines. Frequently this lay is used with the *reverse* lay (parts 2 and 3 of figure 2-8).

The straight lay is made as follows: On the approach to a fire, the truck stops at a hydrant designated on the prefirefighting plans. The plugman steps off the pumper with sufficient line, takes a turn around the hydrant to anchor the hose, and the truck proceeds to the fire, paying out hose from the truck hose load. The plugman removes the 2½-inch cap nearest the fire, removes the loop from around the hydrant, connects the hose to the outlet, opens the hydrant with his hydrant wrench, and proceeds to the fire, straightening out kinks and bends in the hose on the way.

When the truck arrives at the fire, a hose clamp is applied to the hose, and sufficient working line (determined by the crew chief) is removed from the truck by a hoseman, who grasps one or more folds and walks backward till the loop or loops are clear of the truck. Then he goes back to the truck and repeats

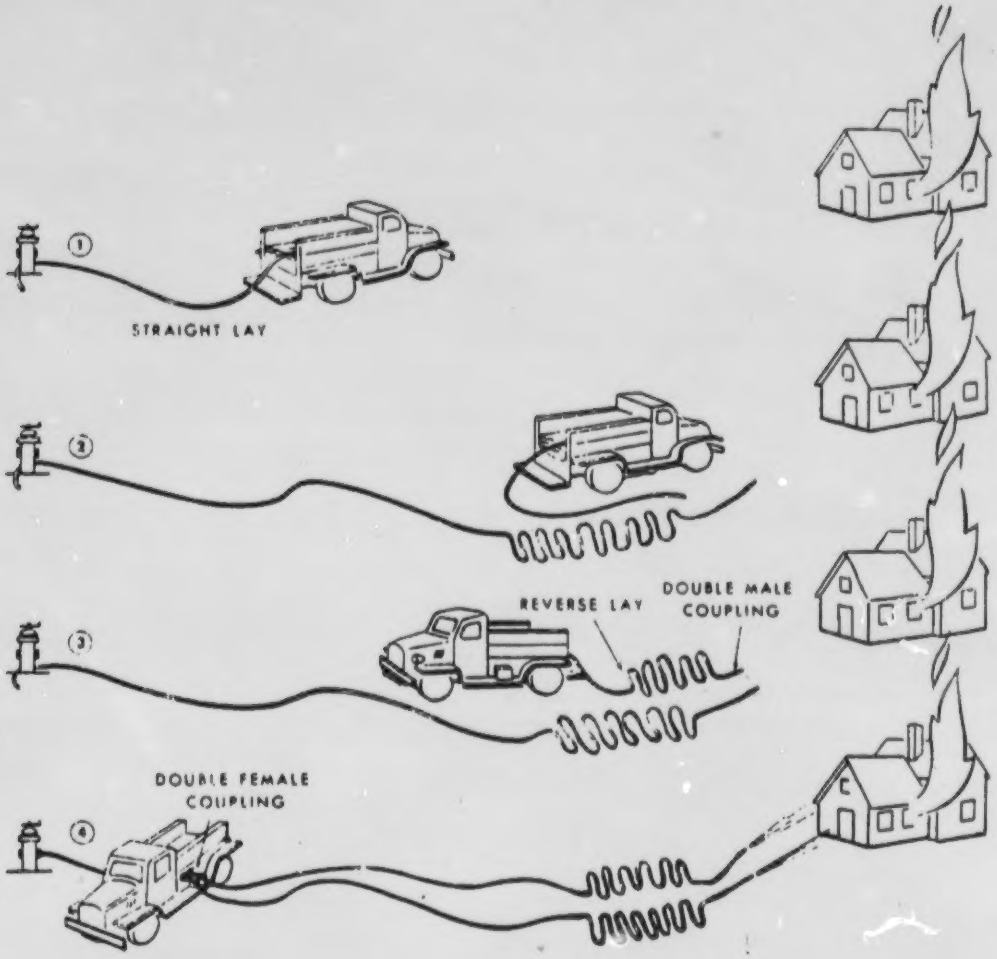


Figure 2–8. Laying the straight and reverse lays.

the procedure. Each loop is laid nearer the fire. When enough line has been removed, he disconnects the nearest coupling, puts the loose end back in the truck bed, and connects the nozzle to the hose. He then removes the hose clamp from the hose to allow the water to flow, and advances to the fire. NOTE: It is good practice for the driver to stop the truck about 75 to 100 feet beyond the nearest point to the fire. This gives the hoseman additional working line.

Reverse Lay. In the reverse lay, the hose is laid from the fire to the hydrant as shown in parts 2 and 3 of figure 2-8. This lay is used when the hydrant pressure is not strong enough to support good fire streams. Although the time required to make a reverse lay may be a little greater than for the straight lay, the assurance of consistent pressure from the pumper compensates for the small loss of time. As we previously stated, this lay may be used in conjunction with straight lay.

To make the reverse lay, the truck should stop 75 to 100 feet short of a point nearest the fire to give additional working line. The hoseman removes the working line by pulling a skid or other hose load. With the working line removed, the nozzleman starts advancing the line to the fire. While the nozzleman is occupied, the crew chief, the driver, and the plugman remove any other equipment that may be needed, such as ladders, forcible-entry tools, portable lights, and the pile pole. This equipment should be placed off the road and on the fire side of the truck. The crew chief kneels on the hoseline to anchor it as it pays out, and then proceeds to the fire to aid and supervise the nozzleman. NOTE: This sequence is flexible. The crew chief may have the hoseman anchor the hoseline while he proceeds to the fire.

The driver and plugman remount the truck, with the plugman riding at one side of the tailboard to avoid injury from the hose and couplings as the load is paid out. After making sure that a crew member is anchoring the hose, the driver drives the truck to the hydrant, leaving the 75 to 100 feet of hose or working line. Stopping at the hydrant, the driver puts the pump in gear, dismounts, and connects the soft suction hose to the truck and then to the hydrant. The plugman dismounts, disconnects the discharge hose at a coupling (making sure there is sufficient hose to reach the pump); then he returns the loose end of the hose to the hose bed. He next carries the end of the hose that leads to the fire around to the pump on the side opposite the hydrant and connects the hose to the discharge outlet of the pump. He may, if necessary, assist the driver in connecting the soft suction hose to the hydrant. The hydrant valve is then opened, and the plugman proceeds to the fire, checking the hoseline for leaking couplings and kinks, and reports to the crew chief. The driver always remains at the pump controls while the pump is being used.

General Principles of Layout. Any crew making a layout either during a drill or during an actual emergency must understand the principles of fire hydraulics (presented in a previous volume of this course) in order to compute such things as friction loss and flow. The hose layouts carried out during drill periods should reflect the potential firefighting demands of the individual base. In areas where extremely large fires are possible, it may be well to concentrate on drills containing layouts where large water volumes and pressures are needed. Under these conditions, it may be advisable to establish a preassigned procedure for each piece of apparatus. The apparatus that is normally "first in," that is, first to arrive at the scene of a potential fire, should be given priority.

Exercises (A10):

1. The plugman takes sufficient line and anchors the hose around the hydrant, and removes which 2½-inch cap?

2. When is the hose clamp applied on a straight lay?

3. When the hydrant pressure is not great enough to support a good fire stream, what type of hose lay is needed?

4. On a reverse lay, who rides on the truck to the hydrant?

A11. Cite selected steps in advancing the hose lines.

Advancing the Line. The most frequently used method of advancing the line is as follows: If you are the nozzleman, face away from the fire, put the hose over either shoulder, with the nozzle hanging downward at your back, and then turn (to the right if the hose is over your right shoulder or to the left if over your left shoulder) to face the fire. The hose will extend across your chest and under your arm, as shown in figure 2-9. Advance to the fire.

If you are following the nozzleman, carry the hose by the shoulder carry or the underarm carry, as shown in figures 2-10 and 2-11. When you use the shoulder carry, you should place the hose on the shoulder opposite to the shoulder the nozzleman uses. This keeps the hose from dragging in front of your feet. The underarm carry is particularly good for advancing lines at street levels. Underarm loads can be picked up easily and quickly.

Advancing hose up a ladder. When you advance a 2½-inch hose up a ladder, it should be a dry line, if possible. A hose full of water is difficult to move and maneuver. If the line is already charged, you can save time and effort if the line is first "broken" and drained before you attempt any extensive advancement. When men are advancing an empty line up a ladder, they should climb about 10 to 12 feet apart, with the hose between them, as shown in figure 2-12. As the operation progresses, additional hose must be fed or passed to the men on the ladder, to prevent the line from fouling. When enough hose for adequate maneuvering has reached the desired height, anchor the hoseline with a rope hose tool, a chain, or a strap to a fire wall, a window sill, or the ladder itself. Make the anchor directly below a coupling to remove the strain of the hose and water weight from the lineman.

Advancing hose up a stairway. Hose is difficult to drag, even in an open, unobstructed area, and it is exceedingly difficult to maneuver around such obstructions as by a stairway. Time and energy may be saved if the hose is carried. You will find that the underarm carry is superior for stairway work under most conditions. If the hose has been properly removed from the truck, you can quickly grasp an armful and proceed up the stairway, as shown in figure 2-13. Again, advancing the hose is much faster and easier if the line is kept dry until the fire is approached; you can do this by keeping the hose clamp in place until the proper time for its release.

Advancing hose with a rope. Frequently, you will find it necessary to use a rope to take a hoseline to an upper window or over a roof parapet. The rope should be dropped from above by someone who has already carried the coiled rope to the desired level. Secure the rope to the hose and nozzle as shown in figure 2-14. Turn the nozzle back and secure it to the hose to prevent damage to it. (The nozzle need not be turned back when the hose is lowered.)

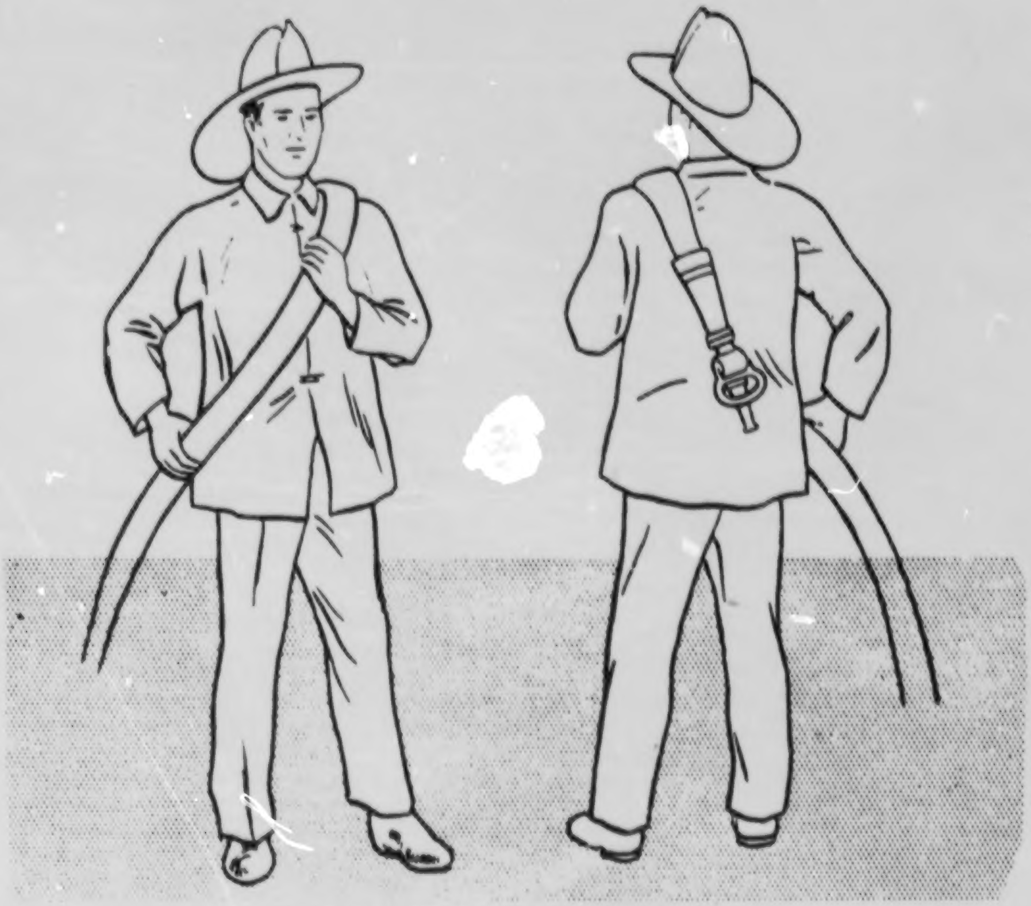


Figure 2-9. Carrying nozzle in cross-chest position.

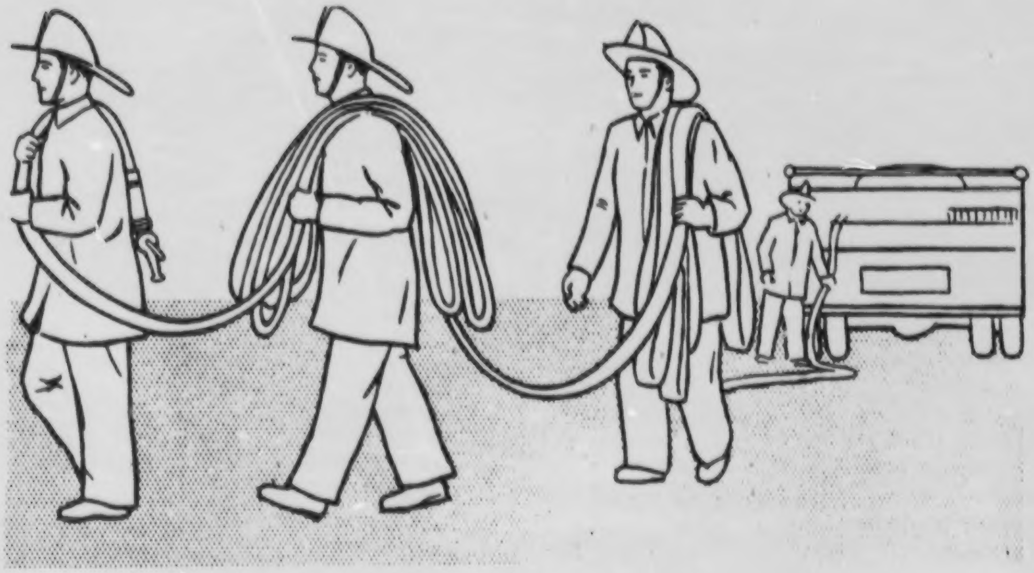


Figure 2-10. Shoulder carry.

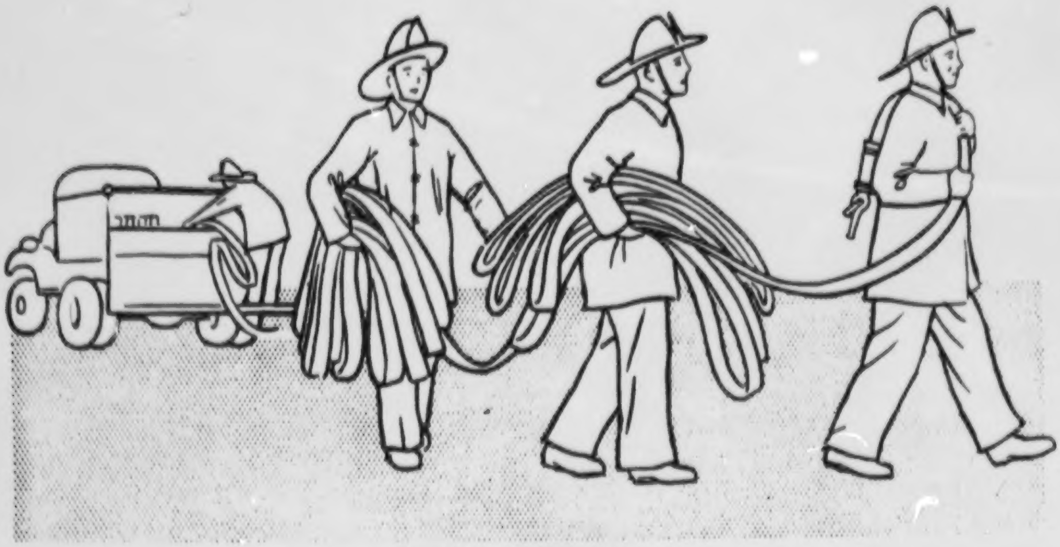


Figure 2–11. Underarm carry.

Exercises (A11):

1. If the nozzle man is carrying the hose over his left shoulder and the man behind the nozzle is using the shoulder carry, what shoulder will the hose be on?

2. When they are advancing a hose line up a ladder, the firefighters should be how far apart when climbing the ladder?

3. What type of hose carry should you use when you are advancing hose up a stairway?

4. Why should you turn the nozzle back and secure it to the hose when you are raising the hose with a rope?

A12. Describe correct ways to handle fire hose.

Replacing a Section of Hose. A hoseline does not normally RUPTURE if it has been properly handled, maintained, and inspected. Nevertheless, sometimes RUPTURING does happen, and any firefighting organization can suffer serious consequences if it has not been trained to handle ruptured lines. If a hose ruptures, the ruptured section of hose should be replaced AS SOON AS POSSIBLE, USE TWO SECTIONS TO REPLACE ONE SECTION OF RUPTURED HOSE.

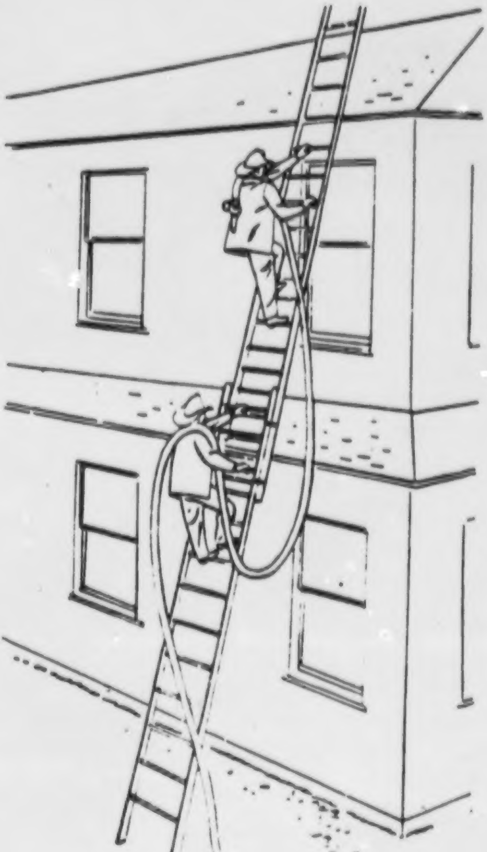


Figure 2–12. Advancing a line up a ladder.

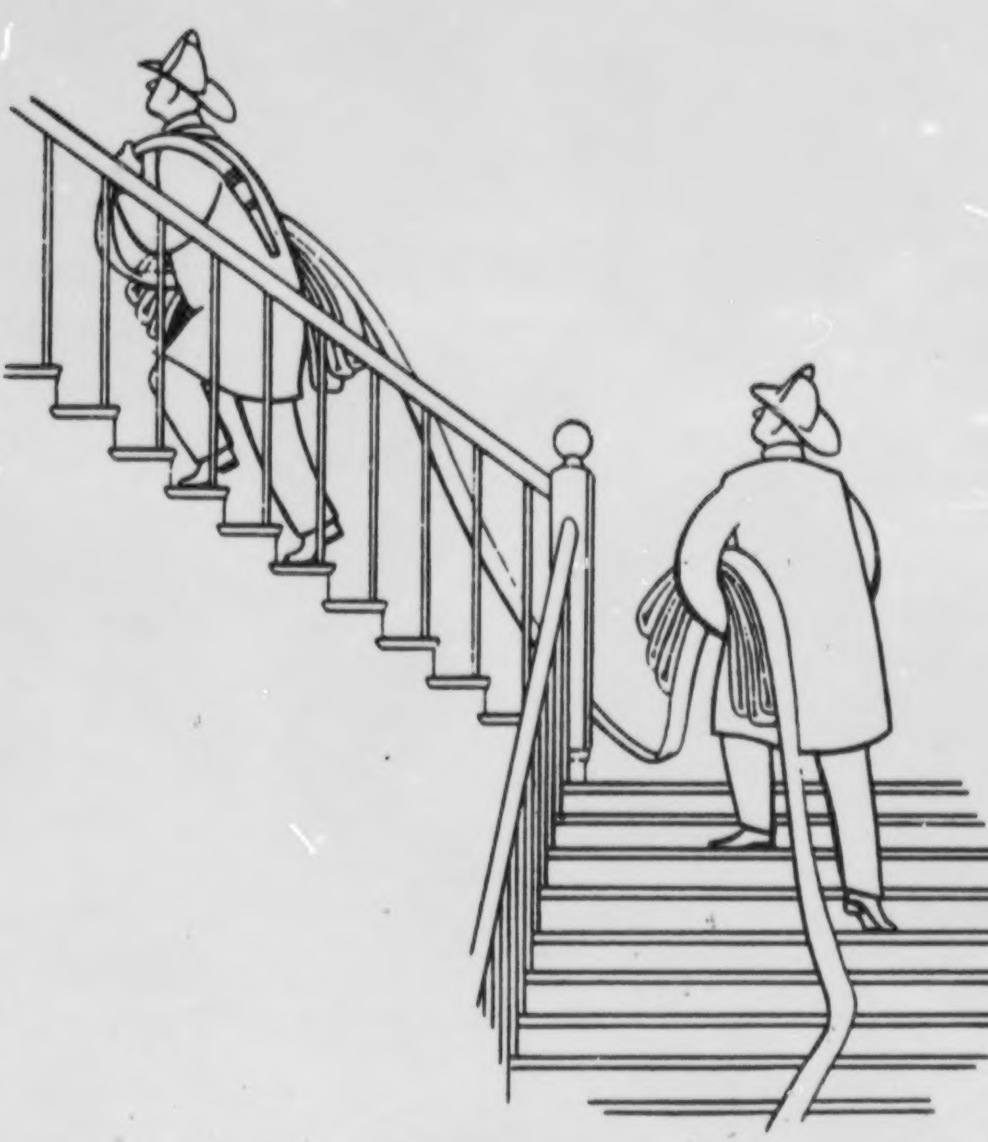


Figure 2–13. Advancing a line up a stairway.

THIS PRACTICE IS NECESSARY DUE TO THE AMOUNT OF STRETCH IN A CHARGED LINE. THIS PROCEDURE REQUIRES SHUTTING DOWN THE LINE. YOU DO THIS BY KINKING THE HOSE (BENDING THE HOSE BACK ON ITSELF), AS IS SHOWN IN FIGURE 2-15, OR BY USING A HOSE CLAMP. THE HOSE CLAMP IS USUALLY USED IF IT IS AVAILABLE. THE HOSE CLAMP OR THE KINK IS PLACED BETWEEN THE RUPTURED HOSE COUPLING AND THE SOURCE OF WATER. WHILE THE REPLACEMENT SECTIONS ARE BEING CARRIED FROM THE APPARATUS, REMOVE THE RUPTURED HOSE. ALWAYS SEE THAT THE COUPLINGS ARE NOT DRAGGED, DROPPED, OR DAMAGED IN MOVING AND THAT THE MALE AND FEMALE COUPLINGS ARE PROPERLY PLACED TO MAKE THE CONNECTIONS.

Lengthening a Hoseline. Take every precaution to provide sufficient hose to reach any portion of the structure that may be ignited by the original fire. Frequently, a 2½-inch line is used to feed 1½-inch lines that are easier for working in confined spaces

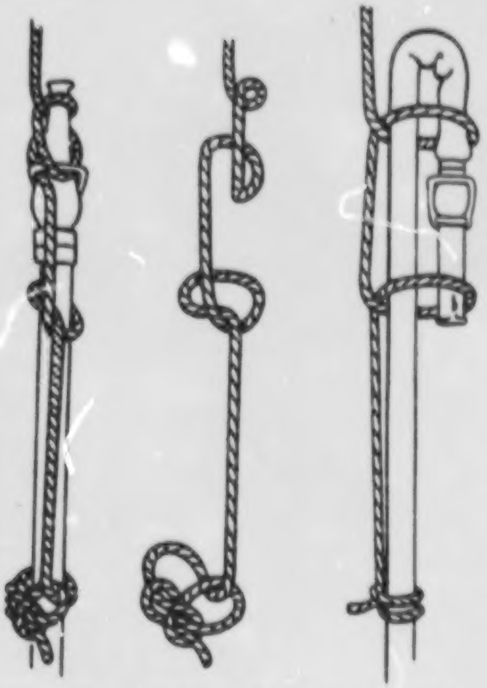


Figure 2–14. Hoisting and lowering a hose with a rope.

and for overhaul purposes. At times the 2½-inch line must be advanced. If a line must be lengthened, two men should take the extra hose they need from the truck and, using the shoulder carry, go to the end of the line. The procedure is shown in parts 1, 2, and 3 of figure 2-16. When the second man is approximately 25 feet beyond the end of the line to be lengthened, he lays the hose on the ground and goes back to make the connection. He couples the line while the first man continues paying off hose from his shoulder. The first man then completes his connection, and water is readmitted into the hose when the signal is given.

Moving hoselines. Dry and uncharged hoselines must frequently be moved from one location to another. When a great quantity of hose, such as several lengths, must be carried from one location to another, it requires the coordinated effort of several men to complete the task with any degree of speed and order.

Shoulder loads are formed by the first man, who starts with the nozzle, or free end of the hose, and places several layers or loops of hose over his shoulder. The loops are allowed to drop over his shoulder in front and back, but they must not interfere with his mobility. The next man leaves approximately 10 feet between the man in front of him and the point where

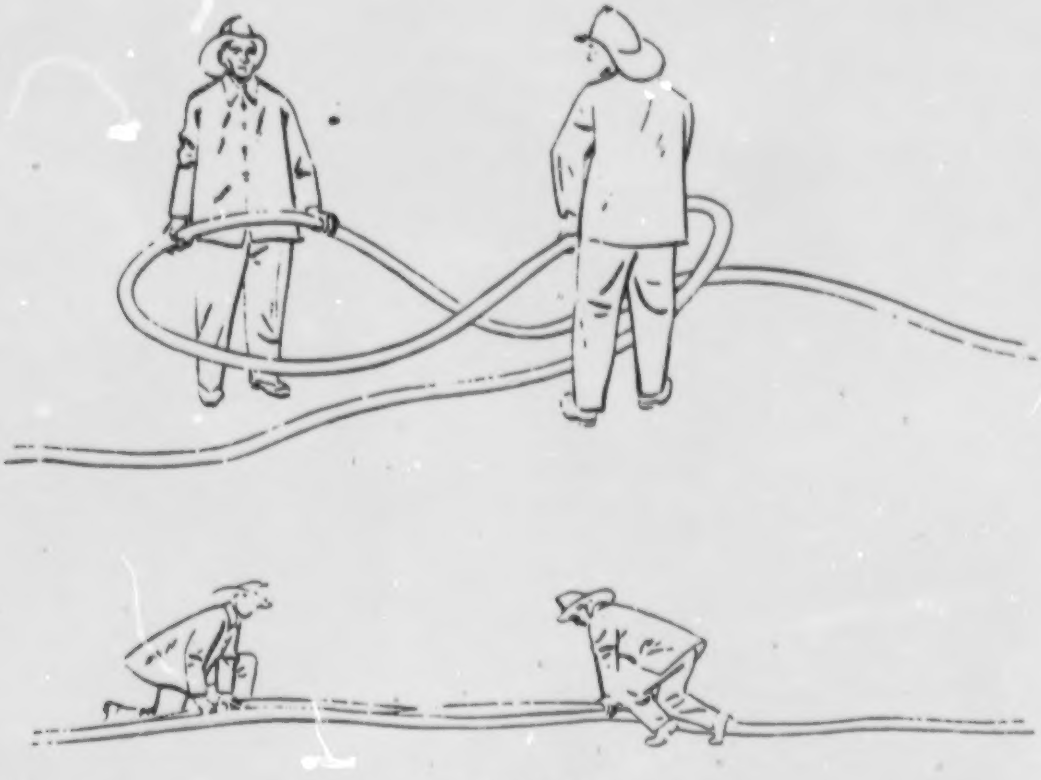


Figure 2–15. Kinking a charge line.

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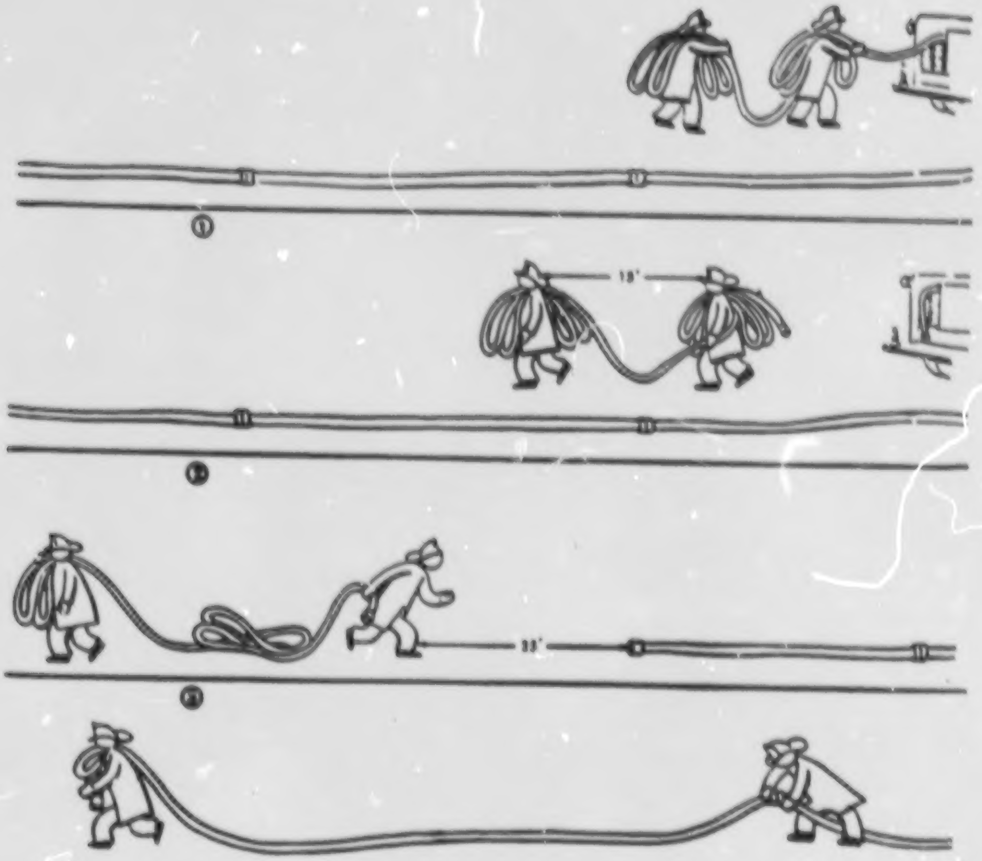

Figure 2–16. Lengthening a hoseline.

he starts forming shoulder loads. This operation continues until the prescribed quantity of hose has been moved or until all available manpower is used.

When you must carry a single 50-foot section of a hose to a given location in order to lengthen or replace the hose, place the main body of the hose on your shoulder and hold it with one hand. Use your other hand and arm to hold both couplings to keep them from dragging on the ground.

If you need a small piece of additional hose to reach the fire or to move the hose to another area and the hose is filled with water, form a loop in the line and roll it toward the nozzle. This operation removes much of the zigzag slack from the line and increases nozzle mobility and stream range efficiency — both from the standpoint of reducing friction loss and increasing efficiency of range.

Frequently, when a nozzle is operated from ground level, manpower is insufficient or the nozzle pressure is too great for safe handling. You can remedy this situation to a reasonable extent by shutting off the nozzle and making a loop in the hose. Then, by tying the nozzle slightly ahead of the loop, as shown in figure 2-17, and turning the nozzle back on, you alone should be able to handle the line and direct the stream. Hose looped in this manner has an increased friction loss and a greater tendency to straighten itself. However, if you have to move the hose a great deal, tying the hose in this way is not recommended.

Figure 2–17. Securing hose against back pressure.

Exercises (A12):

1. Name two ways of shutting down a hoseline without going back to the truck or hydrant.

2. When a line is to be lengthened and two men take the extra hose from the truck to the end of the hose to be lengthened, how far should the second man go past the end of the hose?

3. To move several lengths of hoseline, the first of several men picks up hose from the truck. How much space should each man leave between himself and the man in front of him?

4. What can you do to make handling the hose easier if you are the only one on the nozzle and you are going to be in that one spot for a long time?

2-4. Relay Operations, Hose Loads, and Finishes

The word "relay" means to receive and pass on. When two or more pumpers are used in a series so that the entire volume of water from each pumper is passed on to the next pumper in the series, it is called "relay pumping." The last pumper in the relay feeds the hose lines at the scene of the fire.

Success in fighting fires depends upon many factors. One of these is the efficiency of the hose loads. The best method of arranging the hose on a truck so that it will not be damaged or tangled as it is removed from the truck is a matter of judgment based on local conditions. You should know the more common hose loads if you are to become proficient. The hose loads commonly used by the fire department in the Air Force are the "horseshoe," the "accordion," and the "divided" loads. There are also several methods of finishing off hose loads. As in hose loading, the method of finishing off is optional and governed by local conditions.

A13. Cite key steps in relay pumping.

Relay pumping should be used when the distance between the water source and the point where the water is used is so great that it requires too much pump pressure for a single pumper. The pressure needed may be beyond the capacity of the pumper or greater than the hose is capable of handling. Relays can be difficult and time-consuming, and any means should be used that will simplify the process and produce satisfactory results. Radio communication between pumpers is very desirable.

Even though your base fire department has only one pumper, you should study it, since you may be called upon to participate in a relay operation. A study of relay pumping can be a mutual aid project between your base and the local community department. Hold joint practice sessions and relay water in varying amounts. Drills of this nature not only improve pumper and relay operations but also build a good relationship between departments.

Factors Controlling Pumper Relay. Obviously, one controlling but variable factor is the overall distance to deliver the water. The length of the hoseline, then, becomes one controlling factor. The size of the hose is another controlling factor, although most relays are conducted with 2½-inch hose because it is the most common. Another controlling factor is the number of hose lines between each pumper. A study of Siamesed hose lines and how they reduce friction loss in fire hose will reveal the importance of this factor. The number of pumpers used in the relay is a controlling factor because, when the distance between pumpers can be kept at a minimum, the relay problem is easier and a greater volume and pressure can be maintained. Very closely related to the number of pumpers available is the capacity of each pumper. The larger pumpers should be used near the water source. You must know the discharge pressure and volume of each pumper so that all pump operators can coordinate their efforts and operate at approximately the same pressure. With these controlling factors known, basic rules can be developed. All pump operators must know these rules or guide lines to carry out an efficient water relay.

Usually the pumpers in a relay should not operate above 200 psi discharge pressure. This pressure does not exceed the recommended test pressure for fire hose and leaves a margin of safety. If you need maximum capacity, do not exceed the rated discharge pressure of the pump. Each pump operator must know the amount of water flowing. The volume of water determines the amount of friction loss in the hose. The pump discharge pressure is equal to the amount of friction loss, plus the correction for elevation, and there should be at least 10 psi intake pressure for the next pumper in the series.

As we have already stated, all pumpers should operate at approximately the same pressure, if possible, to standardize their operation. The standardization of pressure is exceedingly difficult if the length of hose between the pumpers differs greatly. Open and shut the nozzles slowly to prevent water hammer. Water hammer can burst a fire hose and shut down the entire relay.

When you are starting the operation, an important step is to open the pump drain cocks or an unused discharge opening to bleed the air from the lines between pumpers. It is also a good policy to continually discharge a small amount of water from each pumper to keep the pump from overheating. This discharge should be at a point where it will not hinder the pump operator or bog down the apparatus.

Place the largest pumper at the water source and the smallest pumper at the fire. The relay must be limited to the capacity of the smallest pumper. Extra "work" from the pumper at the source is needed if it is a location where drafting is required. Extra work may also be needed from the pumper at the fire if long lines or a high nozzle pressure is used. Each pumper should reserve 100 feet of hose for emergencies, such as rupture and replacement.

Spacing Pumpers. There are formulas for calculating relay setups to equalize the work done by each pump. In most fire ground operations, each pumper lays out its entire load of hose and hooks up at the end of the lay. The distance between pumpers is often governed by the quantity of hose carried on the pumpers. Usually the placement of the pumpers is not a critical factor, especially if judgment is used in selecting the number and size of nozzles to be supplied at the fire. With proper training and planning, the most desirable layouts can be anticipated.

The most simple and most often used type of relay is a single line of hose connecting the various pumpers. The success of the relay depends on the amount of water that can be moved through this single hose line. The volume of water from a relay setup must be within the limits of the hose lines.

The following rule-of-thumb method was developed for locating the second pumper in a single relay when more than one pumper is being used:

1. Select the nozzle to be used. You must know the required nozzle pressure and the discharge of the nozzle.
2. Using the gal/min flow, find the friction loss per 100 feet of 2½ inch hose.
3. Divide the required nozzle pressure by the friction loss per 100 feet of 2½-inch hose. The answer is in hundreds of feet of 2½-inch hose of an additional imaginary line.
4. Add the length of the imaginary line to the actual total distance required.
5. Divide the total length of the actual distance and the imaginary line by 2. The answer is the distance between the first and second pumper that will equalize the work load of each pumper.

Exercises (A13):

1. When should relay pumping be used?

2. In a relay operation, you should usually not operate above what discharge pressure?

3. When starting the relay operation, why should you open the pump drain cocks?

4. In a relay operation, which pumper should be placed at the fire?

5. To get your imaginary line, what must you do?

6. To find out where to place the second pumper, what must you do?

A14. Complete statements about the three types of hose loads.

Horseshoe Load. The three hose loads used in the Air Force are the horseshoe, the accordion, and the divided load. The horseshoe load with the coupling in the right front corner of the bed, as shown in figure 2-18. Lay the hose from the right corner back along the right side to the rear edge of the bed, then back to the front of the bed, and across the front to the left side, and finally down the left edge. Make another fold, and lay the hose around the bed, back to the right edge, and fold again. However, this time make the fold about 3 inches behind the first fold, so that the folds are staggered. You repeat this process, except that you make the long folds in the right half of the load about 1 inch longer than the fold in the left half. As you complete the layer, you have room to bring the hose from the center across to the left rear corner of the bed. Tuck the hose in between the side of the bed and the hose already laid, along to the front of the bed, gradually working upward until you reach the front left corner. Bend the hose to the right to start the second layer. In the *second* layer, make the folds of the left half longer than the right and, when the layer is completed, lay the hose around the right half of the load. Repeat this procedure until the hose bed is loaded. Then end view at the top of figure 2-18 illustrates this load.

Accordion Load. The accordion load is much simpler. You start it with the coupling in the right front corner of the bed, and lay the hose back and forth the length of the bed, as shown in figure 2-19. The alternate folds in both ends of the load should be about 3 inches longer, so that the folds are less sharp. Also, if

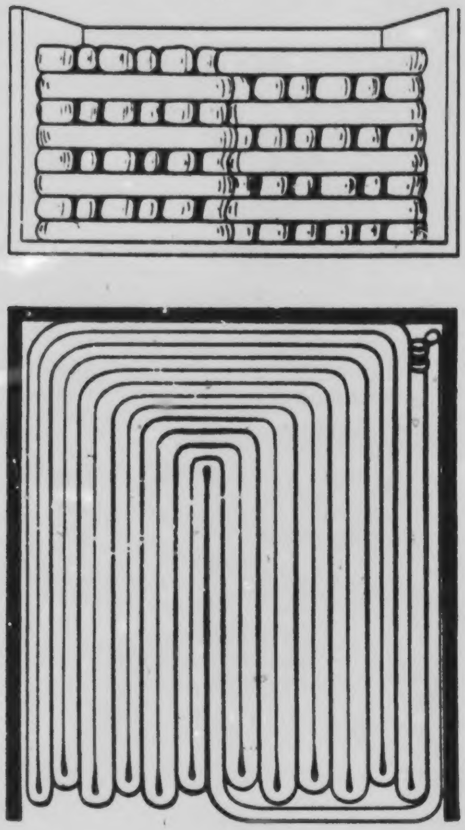

Figure 2–18. Horseshoe load—rear view and top view.

you stagger the folds, you can lay more hose in each layer. When you complete a layer at the end of the bed, raise the hose gradually from front to rear to start the next layer.

Divided Loads. The divided load, shown in figure 2-20, is very useful in localities where fire hydrants are spaced so closely together that only short lays are needed. This load has the added advantage of making it possible to lay two lines of hose simultaneously. You divide the bed by a baffle board and lay the hose in each side separately, using either the horseshoe or accordion load. You can make one single long lay by connecting the male coupling from the top of the left section to the female coupling at the bottom of the right section.

In all three loading methods, be careful to avoid jamming. This can occur if a coupling is forced to turn around in a narrow space while you are removing the hose from the bed. It is a good policy while loading hose to make certain that the coupling can pay out without having to turn. You may need to make a short fold (Dutchman), so that the coupling will not have to turn. This coupling is shown near the left side of the load in figure 2-19.

Exercises (A14):

1. When starting a hose load, you start with the coupling at the __________ corner of an open hose bed.
2. In an accordion load, you start the second layer by gradually raising the hose from __________ to __________.
3. In the accordion load, the folds in both ends of the load should be alternated about __________ because__________.
4. On a divided load, you divide the two hose beds with__________.
5. To keep the hose coupling from having to turn when it is paying out, you may need to form a__________fold.

A15. Describe specified steps in hose load finishing.

Two-and-One-Half-Inch Hose Load Finishes. The 2½-inch hose load finishes discussed here are the most common. The popularity of each may vary from base to base, but you should know all of them.

Doughnut-roll finish. The doughnut-roll finish is used for straight hose lays and can be used with any hose load. Part 1 of figure 2-21 shows how two men make a doughnut roll. Part 2 shows the doughnut roll finished, and part 3 shows the doughnut roll connected to the hose load. The plugman takes the female coupling in one hand and the doughnut roll

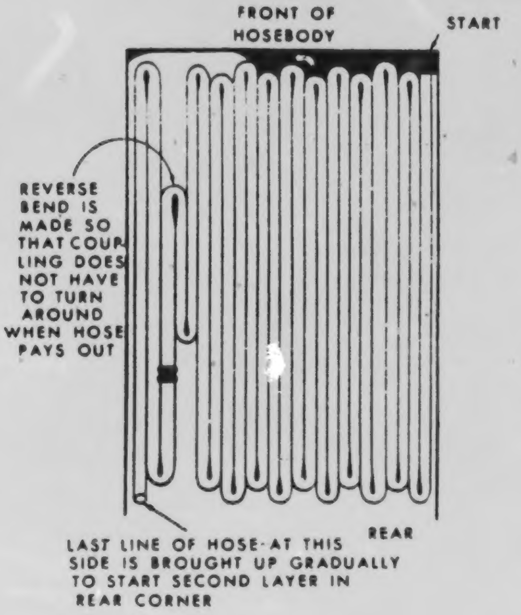
FRONT OF HOSEBODY
START
REVERSE BEND IS MADE SO THAT COUPLING DOES NOT HAVE TO TURN AROUND WHEN HOSE PAYS OUT
REAR
LAST LINE OF HOSE-AT THIS SIDE IS BROUGHT UP GRADUALLY TO START SECOND LAYER IN REAR CORNER

Figure 2–19. Accordian load.

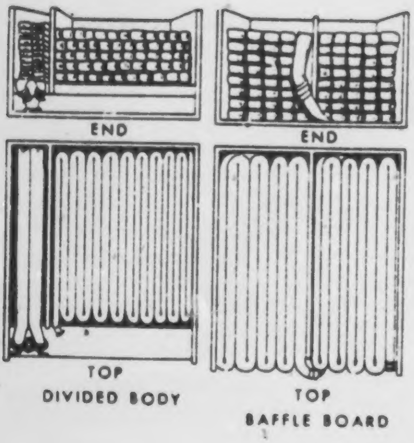

Figure 2-20. Divided load.

under the other arm, steps off the tailboard of the pumper at the hydrant, drops the doughnut roll, and, as the truck proceeds to the fire, makes a turn of the hose around the hydrant to anchor it.

Double doughnut-roll finish. This finish is similar to the preceding finish except that it interconnects two doughnut rolls. This finish is used for either straight or reverse lays. Removing both rolls during a reverse lay is a rapid method of obtaining 100 feet of working line.

Riprap finish. This finish, like the doughnut-roll finish, is used for straight hose lays and consists of hose laid back and forth across the hose bed. The plugman operates in the same way as with the doughnut-roll finish except that he reaches forward and tucks four or five folds of hose under his arm. He then steps off the tailboard, drops the folds, and proceeds as with the doughnut-roll.

Skid-load finish. The skid-load finish is used for reverse hose lays and is very popular because of its speed. You use the last 150 to 175 feet of hose for this finish, setting it up as shown in figure 2-22. Start at the front end of the hose bed and riprap about 25 feet crosswise of the bed. Then make a pair of skids with an 8- or 10-inch overhang at the rear of the bed for handhold loops. Riprap the remaining hose crosswise on the skid with a 2- or 3-inch clearance at both sides and with all couplings riding on the skids. Connect the nozzle to the hose and place it on top. When the truck stops at the fire, remove the load by pulling on the skids. This makes 150 feet or so of working line immediately available.

One-and-One-Half-Inch Hose Load Finishes. There are several methods of loading 1½-inch hose with a 2½-inch hose. One very popular method is the cisco-load finish. To make this finish, you connect two 150-foot lengths of 1½-inch line to a gated wye. Place the nozzle ends of the 1½-inch lines on top, with the nozzles resting on the wye and the tips pointing to the rear. Strap these nozzles to the wye. Now fold the wye end of the 1½-inch line back along the side of the nozzle end of the hose, laying the double line in the center of the body to the front. Fold short, and bring one of the 1½-inch line finishes on the outside of the load; then fold the other 1½-inch line in the same manner on the other side.

Other methods should be tried to determine the method best suited to the need. Some fire departments have installed a baffle board 8 or 10 inches from one side of the hose bed, forming a narrow compartment for 1½-inch hose. The hose can be bedded in this compartment from rear to front, a fold

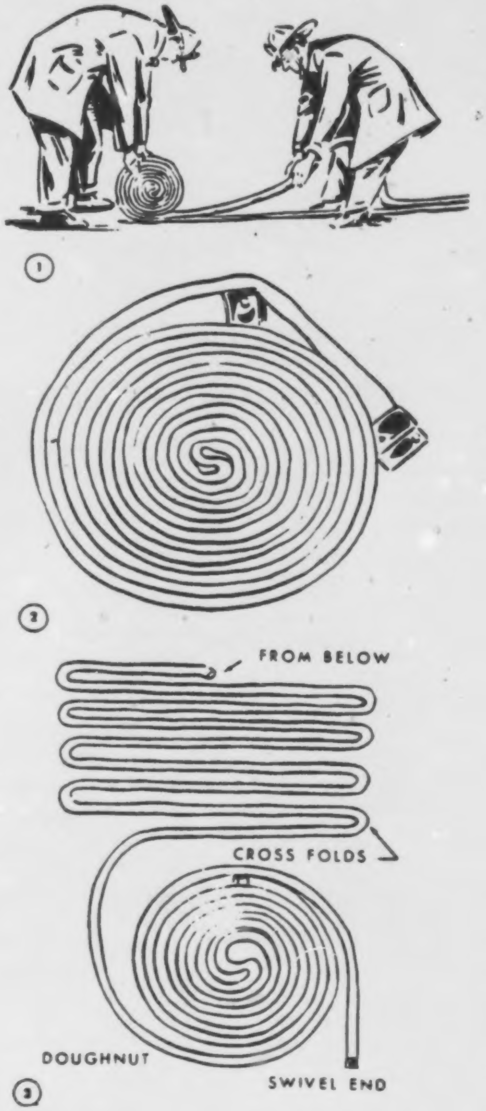

Figure 2-21. Doughnut roll finish.

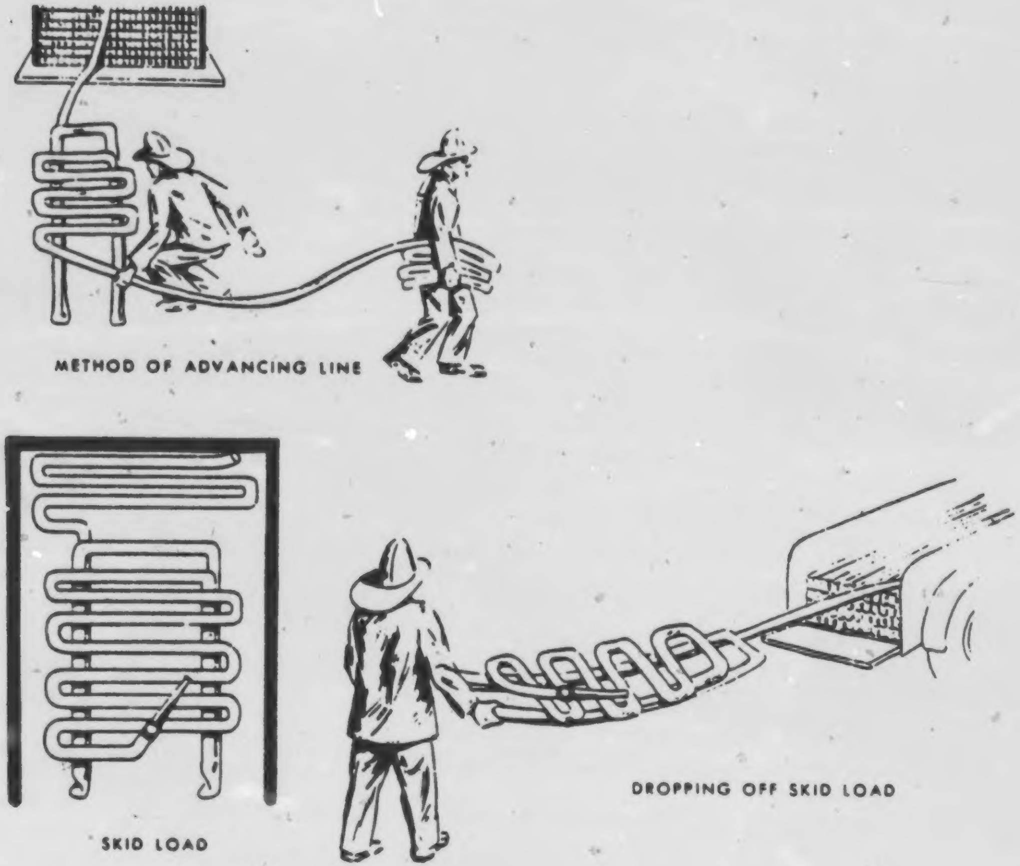

Figure 2–22. Skid load finish.

on top of the preceding fold, with the gated wye at the bottom and the nozzles on top. Another way of using this compartment is to have both lines lead from the gated wye at the bottom of the doughnut roll, and, if more than one length is used from each side of the gated wye, the doughnut rolls of each line are interconnected. Still another widely used method is making a bundle, with the 1½-inch line connected to the gated wye and nozzle; then fold it back and forth in short folds. Hold the bundle compactly with straps or rope and place it on top of the 2½-inch hose.

Exercises (A15):

1. For what type of lay is the doughnut-roll finish used?

2. How much hose is needed to make a double doughnut-roll?

3. When you pull the skid finish at a fire, you should have at least how many feet of working line?

4. To make a cisco-load finish, you must connect the wye connection to the 2½-inch hose; then what do you do?

2-5. Care and Inspections of Firehose

The care a firehose receives is one of the most important contributions to the length of its useful life. The durability, workmanship, and quality of a firehose are primary factors in its selection. But no matter how good the firehose is, you should not expect a full hose life if the hose is continually subjected to avoidable and unnecessary damage. Both natural and synthetic-fiber firehose must receive periodic inspections to detect the possibility of future failure. Instead of waiting until the hose has failed, maybe at a critical time, you should remove it from service for repairs or, in some cases, for salvage. We will discuss firehose repair in the next section. If you perform periodic inspections as outlined, you can greatly reduce hose failure. Not only must your firehose pass certain inspections, but also it must withstand designated tests.

A16. State the reason for selected procedures in the care of firehose.

Handling. Carry hose carefully to avoid dropping it and damaging the couplings. When possible, carry the hose at the couplings. Never drag a hose along the ground, because this results in cuts, abrasions, and punctures in the hose and damaged couplings, threads, and lugs. When a hose is carelessly handled, the exposed threads of the male coupling may be damaged to such an extent that efficient connection to the female coupling is impossible. The female coupling is easily knocked out of round, thus making the entire 50-foot length of hose useless in a layout.

Rough handling is particularly damaging in freezing temperatures. When the hose is frozen, its fabric fibers are weakened and the threads that run lengthwise in the hose are warped. If the frozen hose is not handled carefully, it will break. If the hose is frozen to the ground or the street, you can remove it by carefully chopping away the ice beneath it. Do not remove the ice that remains on the hose. Place the hose in the truck with the least possible bending and forcing and take it back to the station. After the frozen hose thaws out, stretch it out, wash it, and let it dry. Handle frozen hose as little as possible.

Burned Hose. Hose is frequently and unavoidably burned at fires. All hose that has been exposed to fire should be carefully inspected. Turn the hose in to salvage if you find extensive damage at a considerable distance from either of the couplings. If the damage is close to the coupling, you can cut off the damaged portion and replace the coupling.

If hot liquids penetrate the fabric cover of the hose, the lining will be loosened seriously, weakening the hose. Chemical injury cannot always be prevented, especially at fires in chemical depots and warehouses. It is almost impossible to detect the presence of injurious chemicals in the water flowing from a burning structure. Many acids, even when diluted, are capable of staining and destroying the hose jackets, often to the extent of powdering the fiber. If you suspect that acid has come in contact with the hose, examine each length for brown or powdery spots. Wash the exposed portions immediately and thoroughly with a baking soda solution to counteract the acid, and give the hose a pressure test.

Petroleum products, such as gasoline, oil, and grease, cause rapid deterioration of the rubber lining of the hose by dissolving the cement and freeing the lining from the jacket. When a hose is used after having been exposed to petroleum products, the lining tears apart and piles up at one end of the hose. This causes considerable loss of water or complete stoppage of water flow.

Marking Hose. Paint and paint thinner are equally harmful to firehose. Consequently, do not use paint to mark firehose, use a thin application of indelible ink with the aid of a stencil. You may use a metal stamp to impress the hose number in the coupling shank, but be careful when you are stamping the coupling. Too hard a blow on the stamp can crack or deform the brass casting or damage the inside of the coupling. Place the stamped number on the shank of both the female and male couplings. Even a light tap with the stamp on the swivel of the female coupling can knock it out of round, and require further maintenance.

Whether the firehose is marked with indelible ink or a metal stamp, the markings must be uniform. The firehose number should appear on both sides of the hose and at both ends. Marking the hose this way eases the visual identification problem. Marking with numbers is the most common way to mark firehose, but any way that does the job for you is acceptable.

Storing Hose. Proper storage is a vital part of firehose care. To prevent rapid deterioration, store the hose in a clean, dry, well-ventilated location away from hot bright lights, heating pipes, and radiators. Heat and light (mechanical or natural) cause rubber, covers, and linings to become hard and brittle. The racks used to hold the firehose should provide good ventilation for both vertical and horizontal hose rolls. Firehose is almost always rolled for storage in one of two ways. The first roll is called a "straight" roll. To form it, you simply roll one end of the hose toward the other. Usually, you start this roll with the male coupling so that it will be in the center of the roll and the exposed threads will be protected. The other roll is a variation of the straight roll and is named the "doughnut" roll, which you have already studied. Two advantages of the doughnut roll are: (1) both couplings are at the end of the roll and easily accessible and (2) when the hose is unrolled, it has kinks and will not spiral.

Other Hose Dangers. Vibration in the pump and from the engine causes the intake and discharge hose sections to vibrate and chafe the hose jackets against the surfaces they are touching. Serious hose injury results when these surfaces are rough or have sharp edges. The hose closest to the engine can be chafed most severely; farther away, the vibration is absorbed by the elasticity of the hose.

Vibration may be almost imperceptible; yet it can weaken the hose to such an extent that it will fail in a relatively short time. To prevent this, you should insert chafing boots between the hose and the ground at the affected points. If chafing boots are not available, use burlap cloth, rope cushions, or any suitable substitute. The chafing boot is a pad (usually a portion of a section of salvaged hose) strapped or clamped to a hard or soft suction hose during pumping operations.

Hose may be damaged by improper operation at the shutoff nozzle. For example, when the nozzle is closed quickly, the sudden increase in pressure may rupture the hose. If you open the nozzle too quickly, there will be an increase in back pressure, and you can lose control of the hose. The hose nozzle may then injure personnel and damage itself.

One of the most common causes of hose injury is driving a vehicle across hose layouts. Serious damage is less likely if the hose is charged with pressure, but if the hose is empty or under insufficient pressure, the jacket can be separated from the lining and the hose can be ruptured or torn from the coupling. This type of damage can be prevented by hose bridges. Figure 2-23 shows a model of a homemade bridge. Two of them should be built and carried on the truck at all times. After you lay the hoselines, place the bridges over them at the desired spacing, generally about 4 feet apart. If standard bridges are not available, you may set up a suitable bridge with materials found at the scene of the fire. A simple bridge consists of planks, laid on each side of the hose, thick enough to keep the wheels of a vehicle from striking the hose.

When possible, stretch the hoselines on the same side of the road as the fire. Lay the lines parallel to the curb, but not so close to the curb that acid or oil flowing down the gutter can touch the hose. If the lines must cross a street or areaway, lay the hose on the same side of the street as the hydrant, parallel to the curb and up to a point opposite the fire, then across the street. Thus, the fire equipment that follows you need not travel over the hose unless it must pass to the opposite side of the building.

Washing and Drying Firehose. There are two methods of washing firehose: mechanical and manual. Mechanical washing is usually done with a commercially designed hose washer. The washer usually consists of a soaking tub, a series of revolving brushes, a geared roller, and a receiving table. Fire departments located in areas that usually have bad weather are equipped with hose washers. Before firehose is washed in a washer, it is usually prerinsed or presoaked, depending upon the type and amount of soilage.

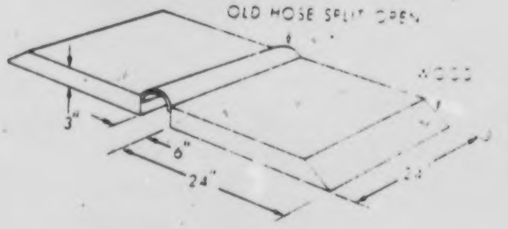

Figure 2-23. Hose bridge.

To wash firehose manually, you must first brush off all the dirt possible. If you cannot remove the dirt by brushing, then rinse the hose with water and scrub it with a brush. If the hose has been subjected to such hard-to-remove substances as oil or grease, remove the spots by washing and scrubbing with a mild soap-and-water solution. Never use any *harsh* detergents. Be sure to flush the soaped hose thoroughly to remove any trace of soap. Even a mild soap can eat away at the jackets and weaken the hose to some extent.

Cotton-jacketed firehose must be dried before storage. Wet cotton-jacketed firehose placed in storage will soon mildew. Mildew is a fungus growth that attacks and weakens the cotton fiber weave of the jacket. The synthetic-fiber-jacketed firehose *does not require* drying before storage, but this action is usually taken anyway.

To dry firehose before storage, drain the water out of the hose from one end to the other. If water remains in the hose for any length of time it tends to absorb the sulfur from the inner rubber lining and form a sulfuric acid solution. The strength of the solution depends upon the length of time the moisture remains in the firehose and upon the temperature. Never let the drippings from the inside of any hose touch the outer jacket of any other hose.

There are several methods of drying hose. The use of a tower is normally preferred. In areas where drying conditions are difficult, an electric hose dryer may be provided. This unit contains racks upon which the hose is laid in a loose roll. The racks are slid into the dryer, the doors closed, the heater and fan started, and the heated air circulated around and through the hose. A hose drying rack (sloped) may be provided if space is available. Be careful not to let the hose remain unprotected from the direct rays of the sun or from adverse weather conditions (snow, sleet, ice, hail, high winds, and dust). Hose-drying racks may be of any size or general arrangement, provided they have a reasonable slope for drainage. These racks can have several layers, but they must be arranged so that water from the ends of the hose on the upper layers does not drip on the lower layers of hose. The drying racks should support the hose throughout its length so that it does not hang in loops that form water pockets. Never hang any section of hose by its coupling.

Exercises (A16):

1. Why must you not drag hose along the ground?

2. If a hose has been exposed to acids, what should you wash it with and why?

3. Why should you use ink to mark firehose?

4. Where should firehose be stored? Why?

5. What is the best method of preventing the hose jacket from separating from the lining when a vehicle is driven over firehose?

6. If the firehose is exposed to oil or grease, how should you wash the hose?

7. Why should cotton-jacketed firehose be dried before storage?

A17. Specify selected procedures in inspecting and testing firehose.

Inspections. Firehose must be inspected after each use and daily, monthly, quarterly, and annually. Each time firehose is inspected, regardless of the time of inspection, the following checks apply:

Inspect the firehose for:
a. Presence of petroleum products, acid, and mildew.
b. Hardness that may be caused by age.
c. Separation of the inner lining from the outer jacket.
d. Heat damage, abrasions, checking, and cracking.
e. Leakage, blisters, and lumps (when under pressure).

Inspect couplings for:
a. Damaged threads.
b. Bent couplings.
c. Binding swivels.
d. Injured expansion rings or sleeves that will cause the coupling to slip from the hose.
e. Broken or damaged lugs.
f. Cracked, broken, or poorly fitting gaskets.
g. Dirt or obstructions.

If these suggested areas of inspection are not enough for your particular needs, add to them.

The after-use inspection includes all the inspection points listed above. The daily inspection of the hose loaded on firetrucks requires a check for dryness, tightness of hose load (which should be loose rather than tight), hose load folds alternate in length, and any visual damage. Hose on or in the drying racks should also be visually checked.

The monthly inspection requires the removal of all loaded firehose, the checking of all points outlined above, and the reloading of the firehose. Remember, never load any firehose into a dirty hose bed. The removal and reloading will change the position of the hose folds and prevent premature cracking of the inner linings. Be sure, when you are removing the firehose from the hosebed, to place it in a clean area.

In the quarterly inspection, all firehose (stored and loaded) must have the inner liner flushed with water. The flushing should continue until the outgoing water runs clear. The annual inspection includes all the inspection points previously mentioned plus the pressure-testing, called "hydrostatic testing," of all firehose.

Hydrostatic Testing of Firehose. Firehose may be hydrostatically tested with a hand pump or a pumper. If a hand pump is available, it is usually preferred. Using a pumper to test hose not only can be dangerous but may result in damage to the engine or the fire pump. All firehose with couplings should be hydrostatically tested. These tests should be conducted annually for all firehose except the unlined standpipe-type hose. Unlined hose should be tested every 10 years.

You connect the firehose to the water-pressure source in lengths no longer than 300 feet. Run the water through the hose until all free or trapped air in the water has discharged from the nozzle. The water pressure during this period should be approximately 100 psi. When all the air has been discharged, close the nozzle. Use the hand pump or the pumper to increase the water pressure to the desired psi. Personnel in the area should prepare to protect themselves from whipping hose because, in some cases, if a firehose fails it whips violently. You can hold the desired pressure between the nozzle and the pump if the discharge gate is closed. Closing the discharge gate minimizes the danger of damage from hose failure, and, the hand pump or pumper need not work so hard. Hold the desired pressure for 5 minutes.

Different kinds of firehose are subjected to varying test pressures. The design and use of the hose play the largest parts in determining the required pressures at which to test the firehose. The following is a list of the different hydrostatic test pressures for firehoses.

PRESSURE	HOSE TYPE
100 psi	Hard and soft intake hoses.
150 psi	1½-inch, single-jacket, cotton-covered, rubber-lined.
	2½-inch, single-jacket, cotton-covered, rubber-lined.
250 psi	1 inch, rubber-covered, rubber-lined.
	1½-inch, multi-jacketed, cotton-and-polyester-covered, rubber-lined.
	2½-inch, multi-jacketed, cotton-and-polyester-covered, rubber-lined.
50% – 100% above working pressure	Unlined firehose.

Test new hose at the proof test pressure marked on the hose at the initial delivery. This test is not the hydrostatic test, but it assures that the hose can be used.

Exercises (A17):

1. When must fire hose be inspected?

2. What does the monthly inspection consist of?

3. What is the best method of pressurizing a hose during a hydrostatic test?

4. How often should unlined firehose be inspected?

5. What is the maximum length of any line being pressure-tested?

6. When the desired pressure is reached, how long should the pressure be maintained?

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CHAPTER 3

Ladder Operations

IN THIS CHAPTER, we will discuss the various types of ladders that are used in the fire service. We will explain how to carry various ladders, how to space ladders properly, and how to raise them. We will also discuss how to climb a ladder safely and how to lock in on a ladder.

3-1. Ladders

Since ladders are vital during an emergency, when every second counts toward the success or failure of an operation, the members of fire protection organizations must know the proper procedures for carrying, raising, and climbing ladders so thoroughly that their actions are governed by habit. Even after the procedures are well-established, they need constant practice to achieve this degree of efficiency. Continuous training should be carried on to make these operations as nearly automatic as possible.

A18. Complete statements about ladders, their types, sizes, and uses.

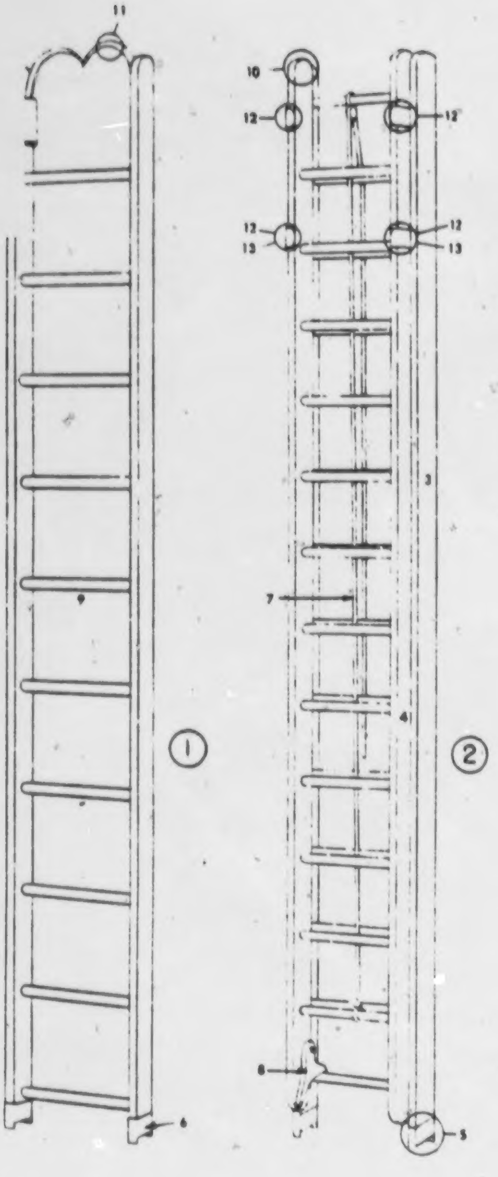
Ladder Terminology. The standard ladders used by the Air Force consist of solid rungs set in the center of the beam. The following terms (with their reference numbers to fig. 3-1) are commonly applied to ladders:

a. Bed ladder – the lowest section of an extension ladder. (3)
b. Fly ladder – the top section of an extension ladder. (4)
c. Butt – the bottom end of a ladder. (5)
d. Heel – the part of the ladder that touches the ground. (6)
e. Halyard – a rope or cable used to raise the fly ladder. (7)
f. Pawl, or dog – the mechanism on the lower end of the fly ladder that locks it to the bed ladder. (8)
g. Rung – the cross member used in climbing. (9)
h. Top, or tip – the top of a ladder. (10)
i. Hooks – to hook over a roof peak, sills, or walls where the heel does not rest on a foundation (found only on roof-type ladders). (11)
j. Stops – wood or metal blocks used to prevent the fly of an extension ladder from extending out from the main ladder. (12)
k. Guides – light metal strips on an extension ladder that guide the fly of an extension ladder while it is being raised or lowered. (13)

Straight and Roof Ladders. Straight ladders and roof ladders contain only one section, as shown in part 1 in figure 3-1. They range in length from 12 to 16 feet. The most common size is the 14-foot straight ladder. The roof ladder is a straight ladder adapted for a special purpose. Hooks are mounted on a movable socket that permits them to fold inward when they are not in use. Placing the hooks over the roof peaks, sills, walls, or coping of any opening makes the ladder safe and reliable even if the heel of the ladder does not rest on a foundation. You can use the roof ladder as a straight ladder if the hooks are set so that they do not protrude beyond the ladder beams. The roof ladder is used on the roof when the pitch of the roof, the material of the roof, or weather conditions endanger the safety of the men who must move over it. It is valuable in gaining access to the peaks of gabled roofs to remove roofing materials or to cut holes for ventilation and extinguishment. The roof ladder may also be used to scuttle holes or cut holes through flooring and sidewalk openings.

Extension Ladders. An extension ladder consists of a bed ladder and one or more fly ladders, as illustrated in part 2 in figure 3-1. The fly ladder, sliding through guides on the upper end of the bed ladder, contains locks (pawls, or dogs) which hook over the rungs of the bed ladder. These secure it in a designated position, dependent upon the desired length of the ladder. The fly ladder is usually raised by a halyard fastened to the lower rung and operated over a pulley on the upper end of the bed ladder. The 24, 35, or 36 foot extension ladders are the types commonly found on pumpers.

Attic Ladder. An attic ladder provides a means of reaching through an opening into attics, lofts, and



(1) STRAIGHT LADDER
(2) EXTENSION LADDER
(3) BED LADDER
(4) FLY LADDER
(5) BUTT
(6) HEEL
(7) HALYARD
(8) PAWL, OR DOG
(9) RUNG
(10) TOP, OR TIP
(11) HOOKS
(12) STOP
(13) GUIDES

Figure 3-1. Types of ladders.

other areas that are somewhat difficult to reach without a special ladder. Attic ladders can be folded or collapsed for small room or closet work. They are usually short because they are required to reach only a short distance.

Exercises (A18):

1. The lowest section of an extension ladder is called ______________________.
2. A rope or cable used to raise the fly of an extension ladder is called a ______________________.
3. The most common length of a roof or straight ladder is ______________________.
4. A straight ladder with hooks in movable sockets is called a ______________________.
5. The sizes of the extension ladders found on structural pumpers are ______________________.

A19. Describe the different ladder carries.

Ladder Carries. During the excitement and hurry of emergency runs, mistakes involving ladders can occur. You can keep these mistakes at a minimum by constantly practicing the proper methods until your actions become automatic.

One-man carry. Frequently a shortage of manpower makes it necessary for one man to carry and operate a ladder alone. One well-trained man can usually do this leaving others free to perform the many tasks needed during an emergency. You can easily carry the roof ladder in the following manner: Remove the ladder from the apparatus and pass either arm through the ladder at the middle of its length. Carry it with the hooks forward and lowered, as shown in figure 3-2.

Though the one-man carry should be limited to short, light ladders and roof ladders, in an emergency you may be the only man to move an extension ladder. If you must, do it this way. Place your shoulder at the center of the extension ladder with the heel of the ladder forward, as shown in figure 3-3. The value of this position lies in the fact that you can set the ladder and raise it in one continuous operation. In a later section, we will cover ladder raises for the common Air Force ladders.

Two-man carry. Normally, extension ladders from 24 to 36 feet in length require at least two men. To remove the ladder from the apparatus, place one man

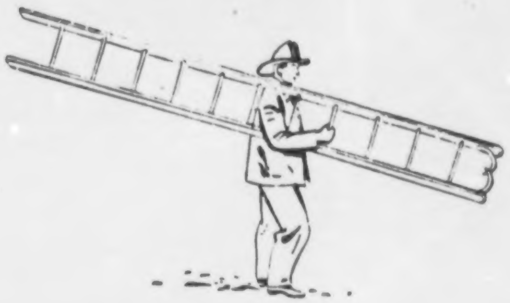


Figure 3-2. Carrying the roof ladder.

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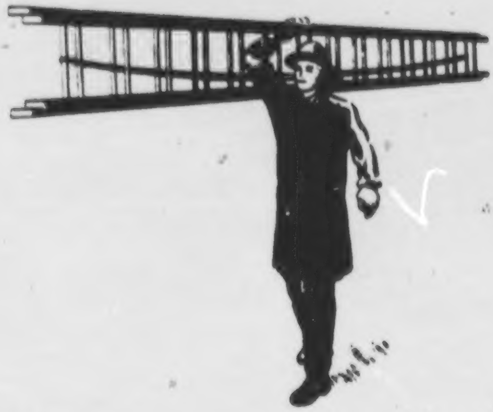

Figure 3–3. Carrying the extension ladder (one-man).

near each end. Each man then passes one arm through the ladder and grasps the second rung forward. Both men must be on the same side of the ladder. Carry the heel forward, as shown in figure 3-4. When he is carrying a ladder in a crowded locality, the lead man can use his outside hand to prevent injury to persons in the line of travel.

Four-man carry. Remove the ladder from the apparatus and place it on the ground with the fly up. Have the four men take positions, two near each end, on opposite sides of the ladder. Face the top of the ladder. Reach down and grasp a rung with the hand nearest it. Raise the ladder on the shoulder, as shown in figure 3-5. Both the four-man and six-man carries are shown in figure 3-5.

Six-man carry. This carry is used for very large or heavy ladders and is the same as the four-man carry except that two additional men are placed in the middle on opposite sides of the ladder.

Exercises (A19):

1. When you are carrying a roof ladder, which end is forward?

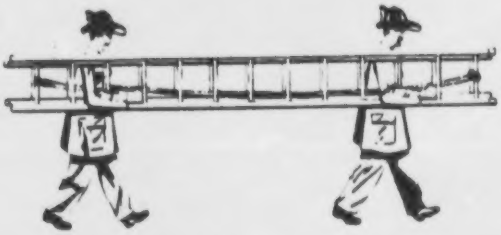

Figure 3–4. Two-man ladder carry.

2. To carry the extension ladder with the one-man carry, what must you do?

3. How many men are required to carry extension ladders from 24 to 36 feet length?

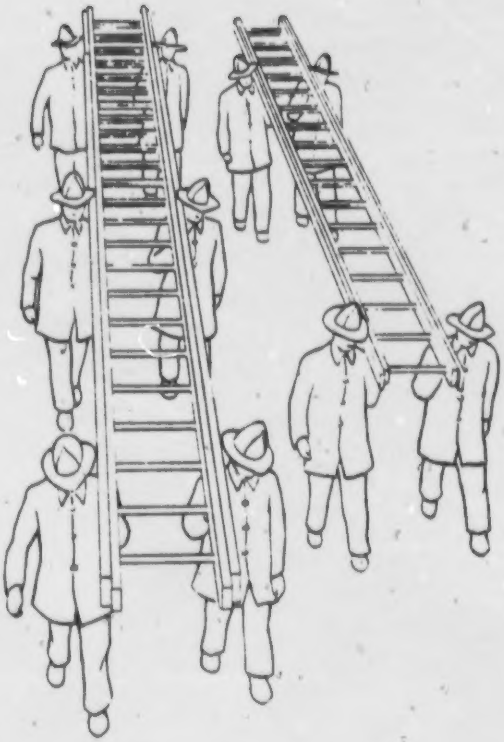

Figure 3–5. Four man and six-man ladder carries.

4. What is the advantage of carrying a ladder with the two-man carry in a crowded area?

5. To carry the extension ladder with the four- or six-man carry, you remove the ladder from the apparatus and place it ________________ .

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A20. Point out selected steps in the various ladder raises.

Ladder Raises. As in ladder carrying, ladder raising requires practice and cooperation. Before you can raise a ladder, you must know how far you should place the heel of the ladder from the building. There are two ways to determine this. One method is to divide the length of the ladder by 5 and add 2. For example, if a 35-foot ladder is fully extended, the heel should be 9 feet from the building (35/5 = 7 + 2 = 9). The other method is simpler. Divide the length of the ladder by 4. If you are using a fully extended 35-foot ladder, divide 35 by 4 and the result is also a distance of approximately 9 feet. (See fig. 3-6.)

One-man raise. There are two methods by which one man can raise a ladder. The first method, while slower, is more adaptable for the beginner. Ordinarily, you use the one-man raise only with short, light ladders and roof ladders. After you carry the ladder to the building, use the following five steps to raise the ladder (look at each step in fig. 3-7).

Step 1 – Place the heel of the ladder against the building

Step 2 – "Walk" the ladder up to the building by using the rungs.

Step 3 – Place the ladder against the building.

Step 4 – After the ladder is in an upright position, lift the ladder off the ground and place it back to the correct climbing angle.

Step 5 – Safety the ladder by placing the ball of your right foot on the bottom rung, then place a hand on the rung. Always look up to see what is going on.

If, in an emergency, you must raise an extension ladder alone, take the five steps in the one-man raise and add the following steps:

Step 6 – Grasp a rung at the head with both hands and pull toward you until the ladder is again in the vertical position.

Step 7 – Place one foot against the side of the beam, steadying the ladder. Let the top of the ladder lean slightly away from you to counteract the pull of the halyard, as shown in figure 3-8.

Step 8 – Raise the extension to the desired height and lock the pawls. Lower the top so that it rests firmly against the building.

The other method of the one-man raise is faster but requires more skill. Carry the ladder as previously explained in the first five steps. When the heel of the ladder is at the desired position, with your hand holding the ladder, start pressing down on the heel. When the heel plates are nearly parallel with the ground, lean forward and give a sharp push with your shoulder. This will set the ladder in the vertical position. Raise the extension as described in the previous paragraph.

Two-man raise. Normally, two men are used to raise straight ladders, and, in certain cases, the extension ladders. Figure 3-9 shows two men raising an extension ladder. Normally, raising the 36-foot extension ladder requires at least three men. Only in emergencies should two men be used. Two people can get into trouble raising the 36-foot extension ladder on a windy day. Before you try to raise the 36-foot extension ladder, we suggest that you practice the three- or four-man raise. The following steps should be followed in the two-man raise.

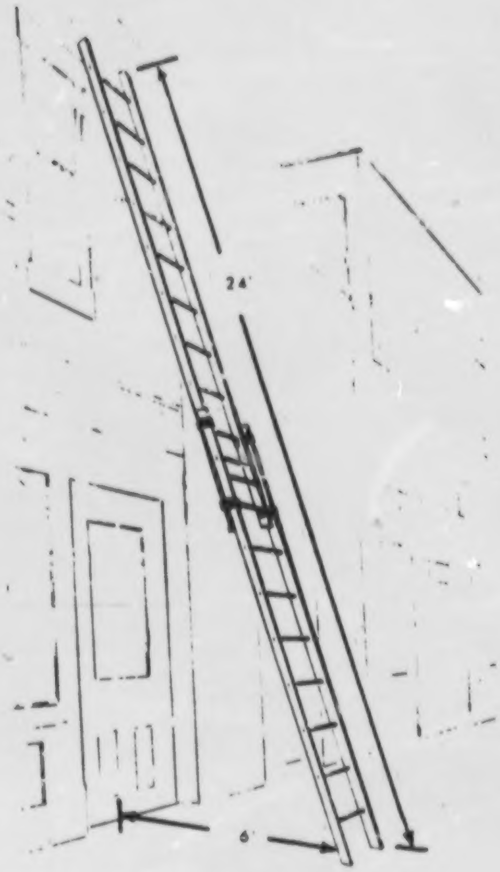

Figure 3–6. Spacing a ladder for proper angle.

Step 1 – Place the ladder close to the building. One man stands at the bottom rung inside to steady the ladder. The other man is at the top with one hand on a rung and one hand on the beam.

Step 2 – The man at the top "walks" the ladder up to the building by using the rungs of the ladder, as shown in figure 3-9.

Steps 3 and 4 – Turn the ladder so the extension is in the correct position for raising. (See the smaller man in figure 3-9 in the front; when the ladder is turned, he is on the inside between the wall and ladder.)

Step 5 – Untie the halyard and raise the ladder to the desired height.

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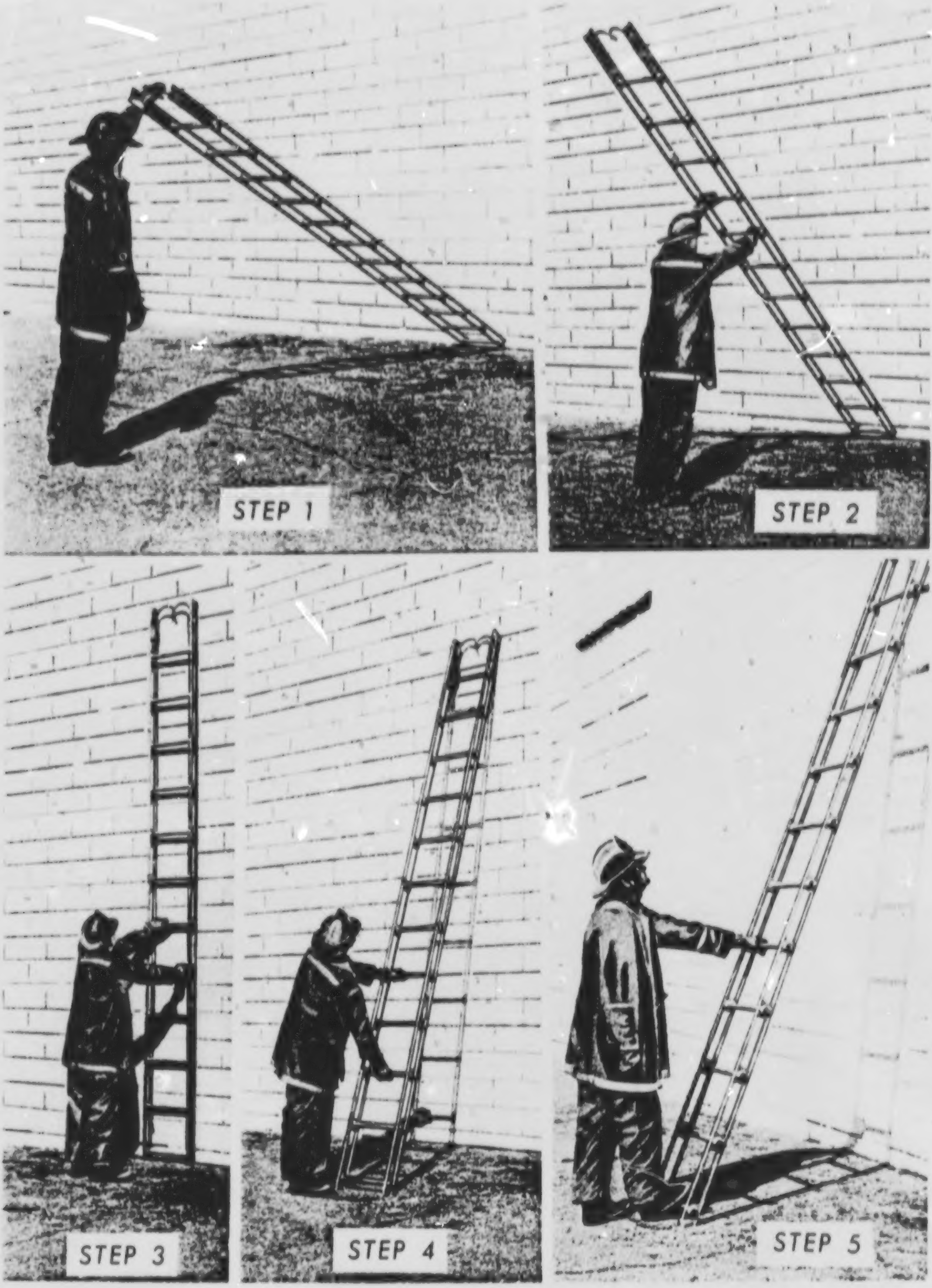

STEP 1
STEP 2
STEP 3
STEP 4
STEP 5

Figure 3–7. One-man raise.

Step 6 – Tie the halyard on the rung and move the ladder out to the proper climbing height.

Three-man raise. This is very similar to the two-man raise, except that two men walk the ladder up to the building and safety it. Figure 3-10 shows the steps to be followed in the three-man raise.

Step 1 – Place the heel of the ladder as close to the building as possible. One man is at the bottom rung of the ladder closest to the wall. The other two at the top holding onto the beam.

Step 2 – The two men "walk" the ladder up to the building by using the beam of the ladder.

Steps 3 and 4 – Turn the ladder so the extension is in the correct position for raising.

Step 5 – Raise the extension ladder.

Step 6 – Tie the halyard on the rung. Bring the ladder out to the correct climbing angle. Two men safety the ladder as shown.

Four-man raise. As we stated earlier, the 36-foot extension ladder should not be raised by less than three people. Four men are better. The four-man raise is very similar to the three-man raise, but two men are used at the heel of the ladder on the four-man raise. The steps of the four-man raise shown in figure 3-11 are as follows:

Step 1 – Place the heel of the ladder as close to the building as possible. Two men are on the bottom rung of the ladder closest to the wall. The other two are at the top holding onto the beam.

Step 2 – The two men at the top "walk" the ladder up to the building by using the beam of the ladder. Since the ladder is always laid on the ground with the fly up, it must be turned after it is in a vertical position. If the ladder is placed against a building with the fly between the building and the ladder bed it loses some structurally designed strength.

Steps 3 and 4 – Turn the ladder so that the extension is in the correct position for raising.

Step 5 – Untie the halyard and raise the extension ladder, making sure the men are in the positions shown in step 5 of figure 3-11; then lock the pawls.

Step 6 – Tie the halyard to the rung and bring the ladder out to the correct climbing angle. Two men also safety the ladder as shown in this step.

Exercises (A20):

1. What is the simpler method of computing the distance between the heel of the ladder and the building?

2. After you raise the extension ladder to the desired height and before the ladder is placed against the building, what must you do?

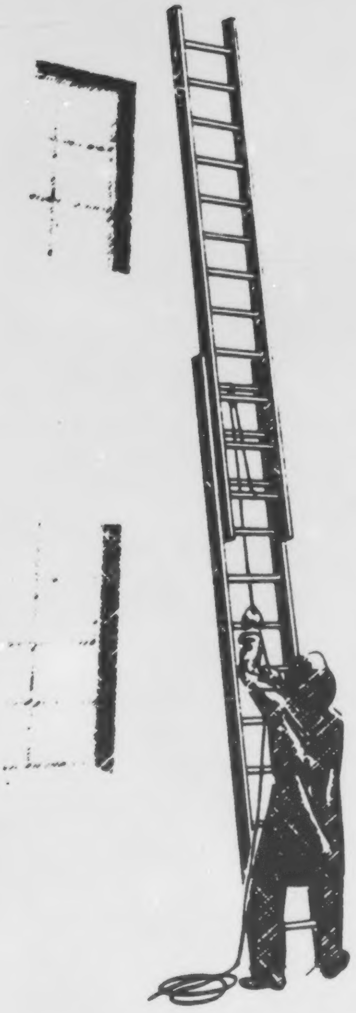
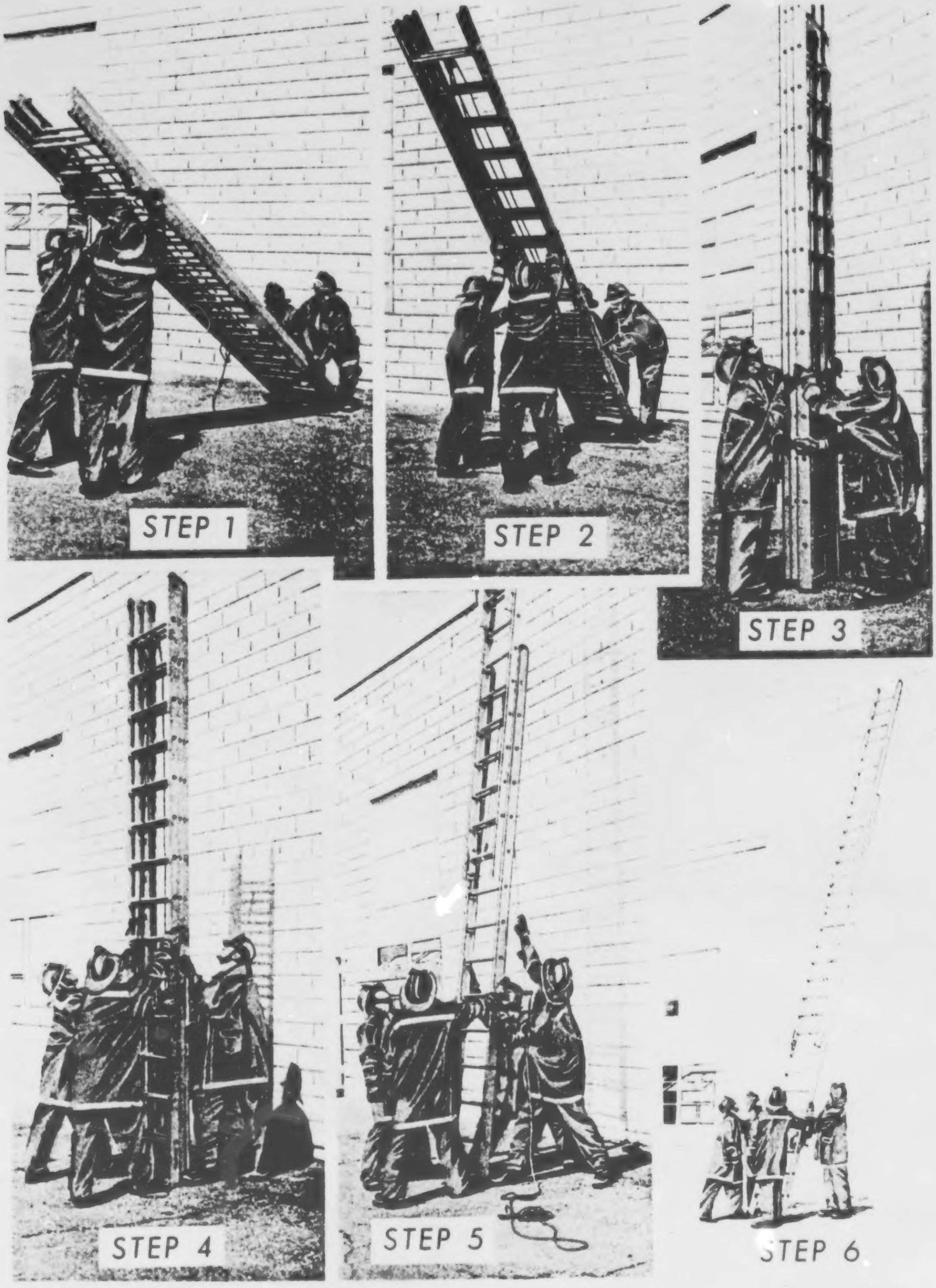


Figure 3–8. One-man raise (extension ladder).

3. On a two-man raise, what does the man at the top of the ladder do after the ladder is placed close to the building?

4. What is the difference between the two-man and the three-man raise?

5. In the four-man raise, after the ladder is "walked" up to the vertical position and before you raise the extension, what must you do with the ladder?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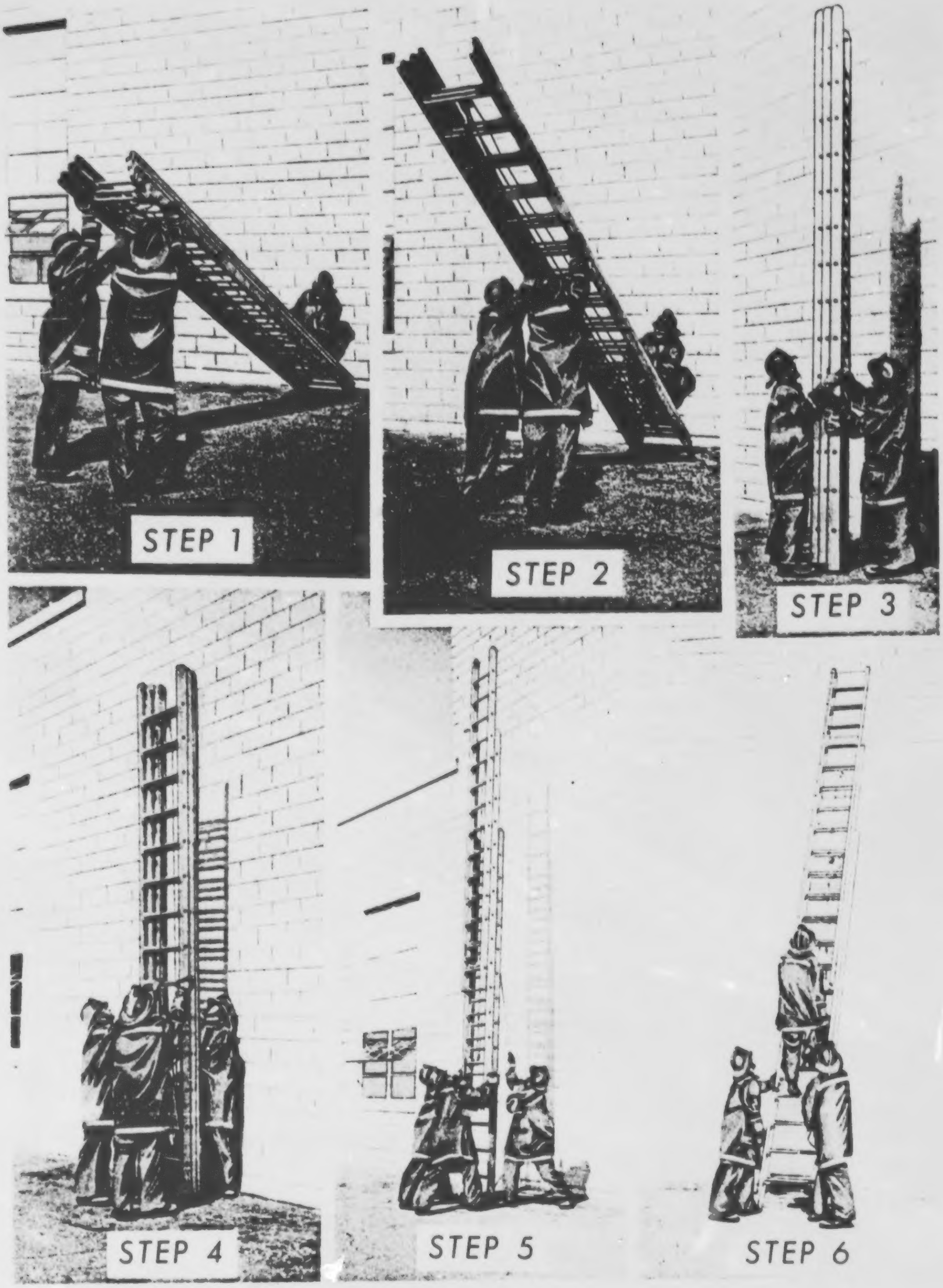
STEP 3
STEP 4
STEP 5
STEP 6

FIGURE 3-11. FOUR-MAN RAISE.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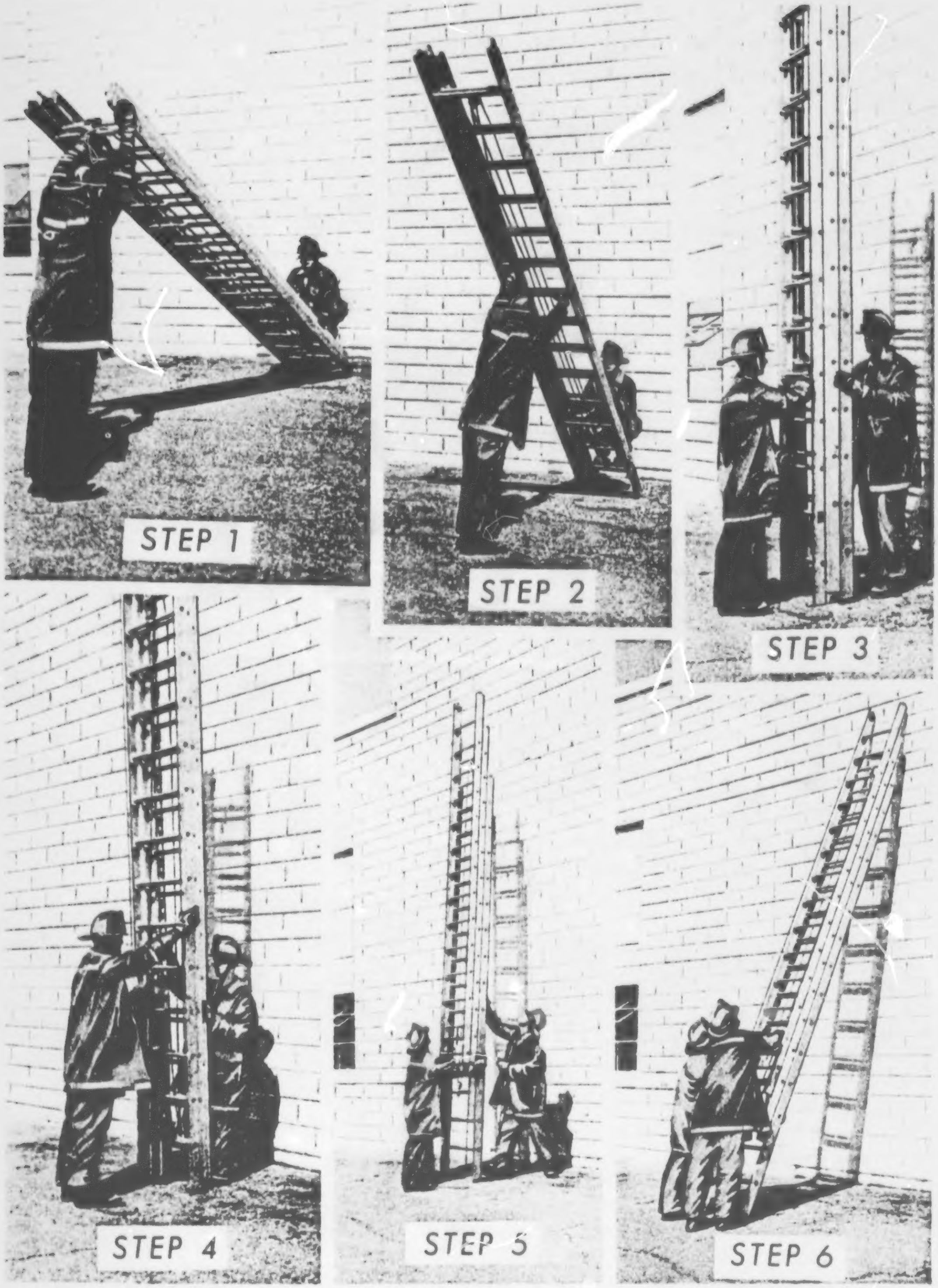
STEP 5
STEP 6

Figure 3-10. Three-man raise.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STEP 2
STEP 3
STEP 4
STEP 5
STEP 6

FIGURE 3-9. TWO-MAN RAISE.

A21. Describe important steps in climbing and locking-in on a ladder.

Ladder Climbing. To the layman, climbing a ladder is like ascending a flight of stairs, except that the ladder is somewhat steeper. For the firefighter, it is not that simple. When you consider that the man climbing the ladder is involved in the duties of rescue, ventilation, and extinguishment, and is moving hose, ladders, and other cumbersome but necessary equipment — all of which take place under the stress of intense excitement — ladder climbing becomes a complicated activity. To acquire ease in ladder climbing and its related functions, you will need a lot of practice.

In climbing a ladder, always keep one hand on one of the rungs, unless you are carrying an article of equipment up or down the ladder. If you are carrying something in one hand, slide this item along the beam, if possible, to afford you at least a limited amount of retention at all times.

There is a more or less unnatural coordination in proper ladder climbing. While one foot or the other must be placed in *every* rung, one hand or the other moves only *once* for each *two* rungs ascended by the feet. For example, if the rungs were numbered from the lower butt upward from 1 through 20, the left hand would possibly grasp rung 4, the right hand would grasp rung 6, and the left would then grasp rung 8. The right foot, if it were the starting foot, would be placed on rung 1, the left foot would be placed on rung 2, and so forth, so that one arm would be moved for each two steps taken on the ladder.

Place your foot in the center of each rung to prevent the ladder from wobbling. For speed and smoothness, you should carry your body in a nearly upright position, with your arms moving outward almost in an arc as you change your hands from rung to rung. Place the ball of your foot on each rung to get complete advantage of the leverage afforded by your ankle. However, where wet or icy weather conditions afford a minimum of traction between your

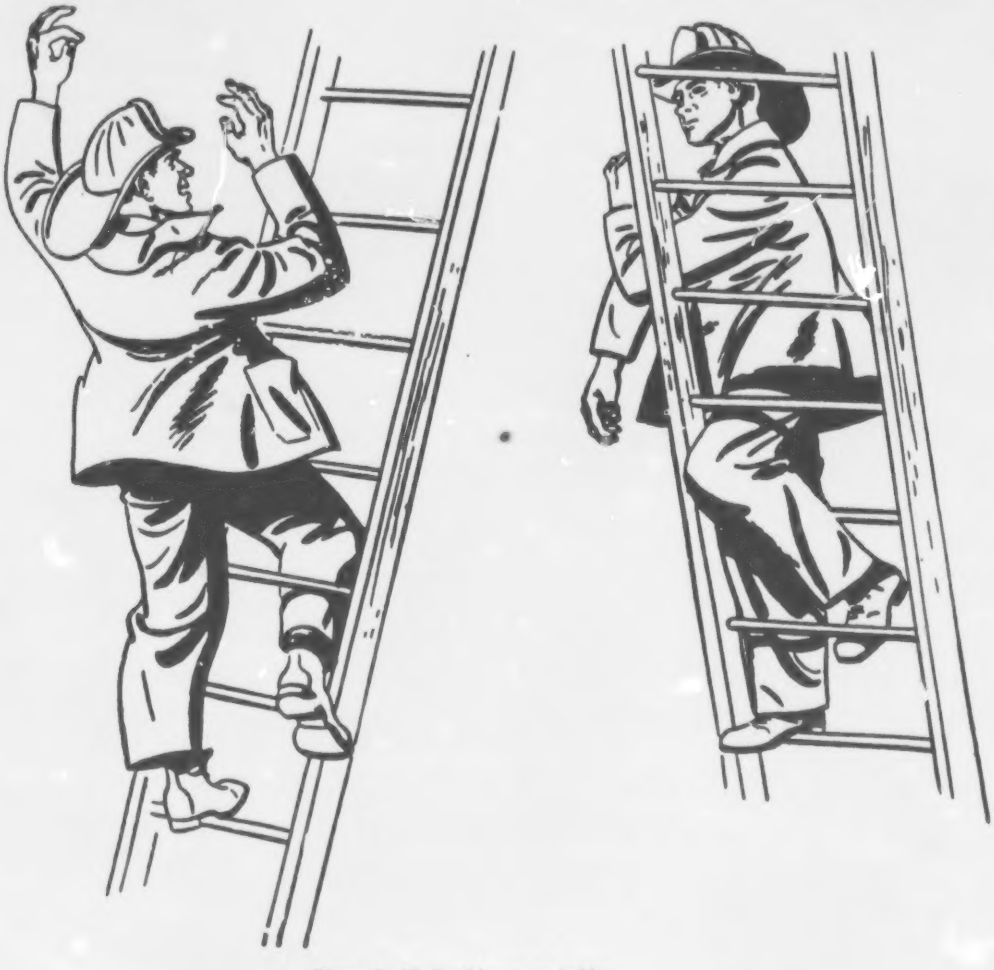

Figure 3–12. Locking-in on ladder.

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boot and the rung, you can place the arch in the center of your boot on the rung as a safety measure. Using the ball of your foot for climbing permits more speed and smoothness and requires less effort. Climb steadily and smoothly and do not run either up or down a ladder. The upper portion of your body should move so evenly that you appear to be standing on an escalator.

Locking-In. Locking-in on a ladder is placing your leg between two rungs and bringing your foot back out between the next lower rungs and locking it either around the rung or around the beam, as shown in figure 3-12. This leg lock enables you to work with both hands free to handle hose, ladders, and tools. You should anchor yourself to a ladder with a rope hose tool or a safety belt only when you must maintain one position for a long time. Short men are more comfortable when they lock one foot around the rung above the one on which the other foot is placed, while tall men usually are more at ease when they lock one foot around the beam of the ladder.

For safety, especially when the ladder bears considerable weight and activity, anchor the ladder to the building with a rope hose tool, a hose chain, or a strap. This anchor prevents the ladder from slipping or turning over when the load is shifted; it also eliminates much of the vibration caused by activity on the ladder. If necessary, take up the slack from the rope by twisting it or making an extra turn around the ladder rung. Remember! Practice and *more* practice in the use of ladders is the only way you will ever develop the proficiency you need.

Exercises (A21):

1. When is the only time you can climb a ladder and not have at least one hand on a rung?

2. If in climbing a ladder, you take 4 steps up the rungs, how many times will you grab the rungs with your hands?

3. Why do you place your feet in the center of each rung while you are climbing a ladder?

4. If you are locking-in on a ladder and have placed your leg between two rungs and brought your foot back out between the next lower rungs, what should you do next?

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CHAPTER 4

Command and Control

IN THIS CHAPTER, we will discuss responding to an emergency, the directing and positioning of fire vehicles, the directing and coordinating of a firefighting operation, and certain features of line attack, confinement, extinguishment, and overhaul.

4-1. Directing a Firefighting Operation

A firefighting operation always begins with the movement of fire vehicles to the site of the fire. You must drive them as rapidly and safely as possible, and when you have arrived at the fire, you must position them where they will be the most useful.

A22. Give some of the rules for a safe emergency response and for pumper placement.

Emergency Response. Always use your beacons, emergency flashers, and headlights when you are responding to a fire. During the daylight hours, other drivers may not see your emergency lights when they are going in the same direction as you are. Flashing your headlights from bright to dim is usually a much more effective attention-getter than your red lights. During the night hours, getting the other driver's attention isn't such a problem.

During night driving, headlights can get the attention of other drivers but can blind an oncoming driver unless they are properly used. It is not necessary to alternate from dim to bright in the dark hours, because your emergency lights will do all that is necessary to warn oncoming drivers of your approach. When you arrive at the scene of the emergency, turn your headlights off.

For the safety of yourself and the crew, always use the siren when you are responding except in housing areas and residential areas where there is a danger of children running in front of you. Children are always fascinated by the sirens and red lights. Always keep in mind that children don't act responsibly and may run directly into your path. At certain times of day, such as after school hours in housing areas on base or in residential districts, it may be wise to drive through without using your sirens. Usually, the first truck gets through without too much trouble, but the following vehicles may have to slow to a crawl to avoid hitting the children.

The siren warns other drivers of an approaching emergency vehicle before the drivers are within sight of each other. Except in the situation we have just described, operate the siren during the response whether you feel that you need it or not. It may save your life or the life of an innocent person. Try to provide an alternating sound, such as "wail," "yelp," or "hi-lo."

Just because you are the one using the emergency lights and audiowarning devices doesn't mean you always have the right-away or that other drivers and pedestrians will automatically yield to you. Many people panic when they see an emergency vehicle, and others don't realize the urgency of your mission. The only thing you can do about the driver who fails to yield is to get his license number and turn it over to the policing agency. You will probably be required to formally charge the driver with failing to yield to an emergency vehicle. This should be done, because it will benefit other emergency agencies in the future.

Always use your safety belts on an emergency response or in normal driving. They should be used 100% of the operational time of the vehicle. The use of seat belts is required by Air Force regulations.

When you are backing an emergency vehicle, whether on an emergency or not, always turn on your beacon light and honk your horn to warn other vehicles and pedestrians that you are backing.

At night, no vehicle is safe when it is traveling faster than 60 mph. By the time you can see something that you should stop for, you cannot avoid it. You will probably respond to an emergency at night and may have to exceed the recommended speed, but remember that you are responsible to the people you serve when you are in an emergency vehicle. You have the proper warning equipment to use in an emergency, so use it. Don't be afraid of drawing attention to yourself because that's exactly what you want to do.

Positioning Firefighting Vehicles. The volume of water needed at a fire, the immediate need for effective fire streams, the availability of water, and your hose and pumper capacity are some of the factors that determine where and how you should spot fire department pumpers. Spotting a fire department pumper to supply hose lines from the tank on the apparatus differs greatly from spotting a pumper to get its supply from a fire hydrant or from a static source by drafting.

Positioning for water tank. To supply hose lines from the water tank on the apparatus, spot the pumper as close to the fire as safety and convenience permit. When you are spotting pumpers for water tank operation, you will use preconnected hose lines, which usually provide a fast attack on the fire. The main disadvantages of using the water tank on the pumper are that the water tank supply is necessarily limited and that the full capacity of the pump is not being used. Always provide for a supplement to the water tank supply before it is exhausted and plan to reinforce the tank operation with other pumpers with large capacity hose lines.

Positioning for hydrant. In most cases, water under pressure is brought to the fire department pumper. The pumper must be connected to the water source with a hose large enough to provide an adequate flow to the pump. Most fire departments use a large soft or flexible hose to supply pumpers from hydrants. The ease and speed of connecting a pumper to a fire hydrant with a flexible hose makes it preferred for intake supply hose under pressure.

When you are stopping a pumper at a hydrant, stop the pumper with the pump intake a few feet short of the hydrant outlet. Stopping short of the hydrant outlet permits the flexible hose to curve, preventing kinks which impede the flow of water.

If a pumper is not equipped with large flexible supply hose, the noncollapsible "hard suction" hose must be used. You should be able to spot your pumper at a fire hydrant for either soft or hard suction hose.

Positioning for draft. To spot a pumper for drafting water, place the pumper as close to the water supply as safety permits. A lift of not more than 10 to 12 feet is preferable. You may connect the intake hose to the pumper before you move the pumper into place. Attach a rope to the intake strainer to hold it off the bottom.

Exercises (A22):

1. When is the only time you would not use your siren on an emergency response?

2. What must you do before backing an emergency vehicle?

3. To pump from a water tank on the apparatus, where should you spot the pumper?

4. If a pumper is not equipped with large flexible supply hose, what hose must you use to connect the pumper to the hydrant?

5. Where do you spot the pumper for a drafting operation?

6. The maximum lift of__________ is preferable for drafting.

7. When spotting a pumper at a hydrant, where should you stop?

A23. Explain specific terms and procedures in an attack on a structural fire.

Attack. Where the word "attack" is used in firefighting, it means "to begin work upon a task, problem, or object of labor." To attack a fire is to begin firefighting action. Such operations as planning, visualizing, and preparing size-up and layout are preparations for attack; but an attack does not start until the first crew comes in contact with the fire. The immediate action phase and future actions by additional crews constitute the fulfillment of an overall attack. We will consider the following factors according to the way in which they influence operations and become part of a fire attack.

Type of fire. A knowledge of the type of fire is most essential to a supervisor when he determines his fire attack because this factor deals with the fuel that is involved and whether a fire is free-burning or smoldering. The incipient phase, the free-burning phase, and the smoldering phase are phases in the development of an interior or confined fire. If a fire has extended beyond the confining walls of a room or building, it is no longer a confined fire. The phase in which a fire is found has considerable bearing upon the type of attack and the positions for attack. As the burning process progresses, the chances for heat control and fire extinguishment are reduced because of the magnitude of the fire and the quantity of heat that is produced. If a fire is progressing and is not checked by the extinguishing medium that is being used, the firefighting forces are on the defensive. To change this situation, adequate extinguishing agents must be provided to increase the attack and direct a more aggressive action on the fire. When fire streams of adequate volume and form are used at advantageous points of attack and heat is absorbed faster than it is generated, the firefighting forces are making headway. This point is the turning point toward an offensive attack.

Water application. Another vital factor in the fire attack is the method by which water is applied. It includes direct water application to the burning material and indirect water application into the superheated overhead space. It includes the use of solid or fog fire streams, or a combination of the two, to provide water in a form that is most suitable for the right type of attack.

The extinguishing property of water is based upon the amount of heat that it will absorb. heat is transferred from the burning material to the water that is applied to it. Water would be the perfect extinguishing medium if you could apply it in a form and at a rate that would totally vaporize it. Unfortunately, this action is seldom possible except under controlled laboratory conditions. The extinguishing action of water is limited when it is applied in the form of a solid stream because the surface of the water that is exposed to the heat is limited. For example, if a cube of ice one inch square, is dropped into a glass of water, it will take some time for the ice cube to absorb its capacity of heat because only six square inches of the ice are exposed to the water. If, however, you divide the cube of ice into ⅛-inch cubes and drop them into the water, 48 square inches of ice are exposed to the water.

This principle also applies to water in a liquid state. If water is divided into drops, the rate of heat absorbed will be increased hundreds of times. Applied in a fog stream, the finely divided particles of water will absorb heat from other materials much more rapidly than they would if applied as a solid stream.

One common mistake that a supervisor makes is not providing enough fire streams when they are needed. He should not hesitate to lay adequate hose lines to back up a fire attack even though he may not need them at that particular time. Fire extinguishment involves not only the choice of fire streams, rate of application, and distribution, but it also involves selecting the points from which the streams should operate.

Exposures. In our discussion of ventilation, we mentioned the need for exposure protection. Here we will consider the way in which exposures become a part of a fire attack. We stated that the three positions of approach to firefighting are at exposures, at avenues of fire spread, and at points of origin. These locations are positions from which a fire attack must be launched and from which fire is controlled and extinguished. An exposure, then, is a position from which a fire attack is made.

If a small structure, such as an ordinary dwelling, is involved, an exposure attack may be made with fog streams from small hose lines. Larger buildings may require an exposure attack with large hand streams, even master stream spray patterns, or water curtains. If a fire has penetrated an exposed building, you must carry the attack into the interior in addition to attacking the opening through which the fire is extending. All roofs, windows, and doors on the exposed side of the building should be protected with adequate fire streams during an exposure attack.

Avenues of fire spread. Fire spreads throughout a burning building by one or more of the following methods: conduction, radiation, convection, and flame contact. Conduction is generally associated with heat transfer rather than with flame. heat is conducted from one body to another by direct contact or through an intervening heat-conducting medium. The amount of heat that will be transferred and its rate of travel depend upon the material through which the heat is passing. The spread of fire throughout a building by conduction should not be ignored, although this method of fire spread is not significant in an initial attack.

Radiation is the transfer of heat from one body to another by heat rays through space. Radiated heat is not absorbed by the air to a great extent and travels through space until it meets an opaque object. An object that is exposed to heat radiation absorbs heat and, in turn, radiates heat from its surface. Radiated heat is one of the major sources of fire spread and demands an immediate attack at points where radiation is severe.

Convection probably has more influence upon the positions for fire attack than either of the previous methods. Convection is the transfer of heat by the movement of air currents. Since heated air expands and rises, fire is usually spread by convection in an upward direction although air currents can carry heat in any direction. Convected heat currents, in many instances, account for the spread of fire from floor to floor, from room to room, and from area to area. The spread of fire through corridors, up stairwells and elevator shafts, between walls, and through attics is mostly caused by the convection of heat currents. Fire also spreads along and through a flammable material by direct flame contact. Fire propagates itself throughout a building by a horizontal, vertical, and downward extension process. For a list of fire extension processes, review these processes in our discussion of ventilation in Chapter 1.

From the standpoint of fire attack, such places as attics, false ceilings, cocklofts, spaces between floor and ceiling, spaces between walls, corridors, vertical openings, and horizontal openings are vulnerable to fire spread. Consider these areas seriously when you are selecting a position for fire attack.

Point of origin. The point of origin of a fire is sometimes quite visible and easily defined, but at other times its location may be completely concealed and difficult to determine. The point of origin is usually where the most intense burning is present, unless the fire has extended to more highly flammable materials or an explosion has caused a rapid extension of the fire. The value of locating the intense burning point or the point of origin is to be able to make a concentrated attack at that point.

In enclosed fires, the point of origin can sometimes be attacked before a fire has had a chance to extend to other areas. You may not need to attack avenues of fire spread and exposures, although you should always be prepared for an attack at these two points. Sometimes fires spread so rapidly that it is absolutely essential to advance an attack at avenues of spread and exposures before you can reach the point of origin.

Sometimes specific conditions become indicating factors and offer very good clues to the point of origin and intense burning. Three of these conditions are detectable heat concentration, color and behavior of smoke, and visible intensity and color of flame. Other factors may also influence a supervisor's decision, but these three factors are the most valuable to him.

Generally, you can detect heat concentration either by feeling the intensity of radiated heat in the walls, doors, windows, and other objects, and by observing cracked glass, discolored materials, and expanded metal. The intensity, denseness, and color of the smoke can indicate the proximity of a fire especially if the smoke is escaping in puffs through small openings. Flame intensity can be used to locate the point of origin only when flame is visible, but visible flame is not a wholly reliable locator because it may be traveling along an avenue of fire spread and this location is not the point of origin. You may also detect intense heat concentration by audible sounds that are characteristic of progressing flame.

Exercises (A23):

1. List the steps in the preparation for attack on a fire.

2. When does the attack on a fire start?

3. What are the phases a fire goes through?

4. When is a fire no longer a confined fire?

5. Name the two methods of water application.

6. Name the two kinds of water streams.

7. Describe the recommended exposure attack on a small structure.

8. Name the four ways a fire can spread throughout a burning building.

9. Define convection.

10. Where is the point of origin usually located?

A24. Define "fire confinement," and cite some supervisory duties during the confinement period.

Confinement. Confining a fire means preventing the fire from extending to uninvolved areas. In our discussion concerning fire attack we stated that, when a fire is not being checked by the extinguishing medium, the firefighting forces are on the defensive, and when an extinguishing agent either absorbs or smothers the heat faster than it is generated, headway is being made. These statements agree with our definition of confinement. As long as the action against fire is defensive, confinement is not possible. A turning point toward an offensive action against a fire constitutes confinement from that point. Confinement is not complete until a fire is stopped from extending to all uninvolved areas. Total confinement means that a fire is under control and is being extinguished.

The principal mediums for confining fire are water streams, other extinguishing agents, and ventilation. The partial extinguishment of a fire usually accompanies the confinement process and total extinguishment is sometimes achieves simultaneously with confinement. Actually, some extinguishment is accomplished when an attack is made and is continuous throughout the confinement period. If a fire is small and the extinguishing medium is adequate, the entire process of attack, confinement, and extinguishment may be accomplished simultaneously.

The confinement process involves a period of time during which firefighting forces attempt to check fire spread. During this period, a chain of events must take place leading toward final extinguishment. Public utilities such as electricity and gas contribute to the spread of a fire and are serious life hazards. Fire service inspection surveys should provide the necessary information about utilities and a supervisor should know how to shut off the electrical and gas supply lines from the burning property.

The valves that control the water supply lines to a domestic system should be closed because broken water pipes cause flooding and excessive water damage. Uncontrolled flow from broken water pipes also reduces the quantity of water available for firefighting. The water supply valves that control the flow of water to private protection devices and fire hydrants should be left open during the entire confinement and extinguishment period. It is vitally important for the supervisor to know the source from which the automatic sprinklers receive their water supply. The pumpers must not rob a sprinkler system of its water supply. Maintaining an adequate supply of water for automatic sprinkler systems is one of a supervisor's first concerns.

The control of water runoff during the confinement of a fire is an aftermath of the application of water. Performing salvage cover operations and routing water from a building are not directly related to fire confinement, but they are functions that should be carried out as soon as possible, even during the confinement period.

The fire confinement period is an eventful time during firefighting when many changes take place. Sometimes these changes are instantaneous, at other times they take considerable time. A supervisor must realize that, although the confinement of fire is a necessary step in the firefighting procedure, it may be partially or completely accomplished during the process of size-up.

Exercises (A24):

1. Define "Confinement" in the firefighting process.

2. What are the principal mediums through which the confinement of fire is made possible?

3. If the fire is equipped with an automatic sprinkler system, what is the supervisor's first concern?

4. What functions not directly related to fire confinement should be carried out as soon as possible, even during the confinement period?

A25. Define fire extinguishment, list the properties or water, and give selected steps in extinguishment.

Extinguishment. Fire extinguishment is the act of suppressing flame with an extinguishing agent. It includes any operations required to stop the burning action. The supervisor must determine the type and kind of extinguishing agent that should be used. His decision should be influenced by the nature and physical state of the fuel that is burning. He must know which extinguishing agent is best suited for each type of fuel, and he determines the volume and the rate of its application by the quantity of the fuel that is burning and the intensity of the heat that is being generated. How to apply the extinguishing agent depends upon the physical arrangement of the fuel and the form of the extinguishing agent.

Generally, when fire involves a building, the burning substances are ordinary, combustible solid materials. These materials require a "cooling-quenching" agent with a high heat-absorbing capacity. Water has certain physical properties that enable it to absorb more heat by volume than most other extinguishing agents. Water is also a very practical and economical agent and, for these reasons, it is commonly used to extinguish a fire that involves ordinary solid materials. In order to employ water successfully as an extinguishing agent, you need a high percentage of water vaporization. If the heat of a fire fails to vaporize the water, the water contributes very little toward fire extinguishment. Water must be converted into steam to absorb its full capacity of heat. This factor is very important, and firefighters should direct fire streams in a way that permits the most effective water vaporization. Extinguishing fire with water is not a complicated operation, but the method by which the water is applied often requires considerable know-how, endurance, and physical stamina. Firefighters are usually able to reach a high degree of efficiency if the extinguishing agent is adequate and properly applied. If there is a decline in extinguishing efficiency, it may be due to lack of experience, inadequate facilities, or improper training and supervision.

Obviously, fires that have reached major proportions present the greatest problem in fire extinguishment. These fires are usually extinguished by degrees. The first step toward final extinguishment is to quench the main body of the fire. This action generally reduces heat generation to a point where the firefighters can either enter the burning area or advance closer to the fire. There are usually spot fires in various places after the main body of the fire has been extinguished.

A second step toward final extinguishment requires a closer approach to these spot fires and a direct application of water to the burning material. Spot fires are of varied size and intensity, and this step in extinguishment is usually the period when area fires are extinguished.

A third step toward final extinguishment is to locate and extinguish hidden fires. Hidden fires or deep-seated fires are quite different from the spot or area fires. Locating and extinguishing hidden fires are sometimes overhaul operations because they are usually done during the overhaul period.

Exercises (A25):

1. Define fire extinguishment.

2. State the physical properties of water that make it a commonly used extinguishing agent.

3. What must happen for water to absorb its full capacity of heat?

4. Give the first and second steps in fire extinguishment.

A26. Explain selected points in overhaul, utilities shut-off, rescue, and evacuation procedures.

Overhaul. The overhaul step in firefighting is a careful check to make sure the fire is out. During overhaul you check the building and the material inside thoroughly to prevent the fire from starting up again. One of the worst things that can happen to a fire department is to have to return to a fire that the firefighters thought they had extinguished. A second fire is much harder to control than the original fire.

Before he starts the overhaul, the supervisor should decide whether or not the building will collapse because of the structural damage and weakening caused by the fire. After he makes this decision, he makes certain that the fire is fully extinguished. The fire may still be burning in hidden areas.

Some of these hidden areas are in false or hanging ceilings and between floor joists, walls, and partitions. You should check the areas around windows, door casings, light and air shafts, and places where pipe or wire go into the wall. When you are checking for "hot spots," place the back of your hand on the area you suspect. For example, if a wall feels warm or is blackened, open the wall and check it. To cut inspection openings, make a square cut near the wall studs to make repair easier. Check attics, basements, and nearby buildings.

Shut Off Building Utilities. In most structural fires, utilities must be shut off. This is properly the responsibility of the civil engineering heating and electrical shops, but it usually must be done before they can arrive at the fire scene. Thus, this responsibility usually falls to the fire department.

While he is responding to a structural emergency, the crew chief checks the prefire plan to familiarize himself with the location of the building utilities shut-off. The utilities lines must be shut off to minimize the hazard of electrical shock and the possible spark that could cause an explosion if the gas lines were ruptured. Before the crew chief shuts off the utilities at the fire scene, the senior fire official should be advised so he can make the decision. He usually has more information about the situation than an individual crew chief.

Rescue Activities. All firefighters should be thoroughly trained in rescue techniques. In addition to his other responsibilities, the supervisor is responsible for the protection of life, and he must see that the occupants of a burning building or those who are endangered by other situations are rescued and evacuated. A properly conducted fire inspection survey contains the occupancy of every building. A fire inspection survey does not plan the resuce and evacuation procedure for the occupants, but it supplies information concerning the probable need for life protection. With this knowledge, a supervisor can size up a life situation realistically and decide on a suitable rescue procedure under the actual conditions. When there are occupants in a building, a serious life hazard exists. Its complexity depends upon the number of occupants present. You can expect a life hazard in the following places:

Apartments
Auditoriums
Churches
Day Schools
Dormitories
Hospitals
Industrial Plants
Nurseries
Office Buildings
Penal Institutions
Schools
Theaters

As the supervisor considers the need for rescue and evacuation, he should also consider the physical and mental condition of the occupants. Are they asleep, awake, injured, bedfast, immobilized? Are they mentally ill, panic-stricken, frightened, composed? These factors, plus the locations where victims can be trapped regulate the type and priority of rescue that may be needed.

To perform a rescue means to take a person out, to liberate him from confinement or danger. Fire Service rescue connotes both individual rescue and group liberation, which cannot be done by an individual. "Rescue" includes using ladders, elevating platforms, carries, drags, rope work, stretcher work, life-net, and lifeline. "Evacuation" means providing a way by which a group of people can be guided to exits and withdrawn from an area. In evacuation, you use such facilities as exits, passageways, corridors, stairways, fire escapes, escalators, and elevators.

In addition to rescuing or evacuating occupants, a supervisor must also keep people from entering a burning building and must guard against other dangers to spectators and fire department personnel. When he knows the structural condition, fire spread, and contents of the building and the fire resistance ratings of the materials involved, he can decide where certain fire vehicles should enter and operate. Because of new or unusual developments during a fire, a supervisor may have to change a previous course of action to protect his men. Protection for spectators requires police cooperation to enforce roped-off areas and maintain an established safety zone.

The Need for Exposure Protection. An exposure, during firefighting, is a structure or its contents that can be ignited by a fire in an adjoining building or other exterior source. Fire protection people also use the term "exposure hazard" to identify a building that is not involved in a fire, but, because of its condition, position, or contents, can become a hazard (see fig. 4-1). A building may be adjacent to another building and not be an exposure hazard because of its fire-resistive characteristics or unpierced fire walls.

The extent of the hazard depends upon the size of the exposure, the distance between the buildings, weather conditions, and the exposures susceptibility to ignition. Exposure conditions vary so greatly that it is not practical to establish set rules to apply in all conditions. Never underestimate the need for exposure protection.

Exposed buildings can be ignited by radiated heat, by direct flame contact, or by flying brands (see fig. 4-1). The possibility of ignition always exists, but the danger is more acute when large quantities of heat are produced. The direction and velocity of the wind and the relative humidity of the atmosphere are also contributing factors toward possible ignition, but the distance between the buildings is probably the most important single factor in the potential danger of an exposure hazard.

Permanent protection against exposure fires can be provided before a fire occurs. The space between buildings can be controlled. Sprinkler fire protection systems can be installed. Although these protective measures are effective and dependable, fire department protection is actually the determining factor in controlling a great majority of exposure fires. The following conditions protect against exposure fires.

a. Open space between buildings, clear of combustibles.

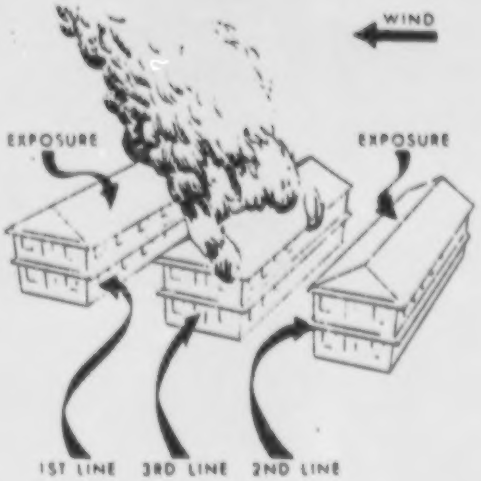

Figure 4-1. Protecting external exposures.

b. Parapeted fire walls without openings.
c. Fire resistive walls with protected openings.
d. Noncombustible roofs.
e. Fire department hose streams.
f. Outside automatic sprinklers.
g. Inside automatic sprinklers.

Exercises (A26):

1. What must be done before overhaul operations?

2. Building utilities must be shut off to minimize what hazards?

3. List the physical conditions that a supervisor must consider in human rescue and evacuation operations.

4. During rescue operations, what procedures may be performed?

5. How are exposures ignited during a fire?

6. What is the most important single factor in the potential danger of an exposure hazard?

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CHAPTER 5

Post-Extinguishment Procedures

IN THIS CHAPTER, we will discuss salvage and overhaul operations, structural stability, the preservation of evidence, and building cleanup. These are firefighting responsibilities that are carried out after a fire is apparently extinguished. We referred to several of these subjects in Chapter 4, but we will go into them in more detail in this final chapter.

5-1. Salvage and Overhaul Operations

Salvage and overhaul are important functions in firefighting. To the greatest degree possible, the firefighter tries to protect and preserve buildings and their contents in case of fire.

A27. State the two ways to perform salvage operations and give some of the important factors in salvaging buildings and their contents.

Salvage. Salvage work in firefighting is preventing excessive damage by fire, smoke, and water. Keeping fire loss at a minimum requires a knowledge of salvage operations and the ability to improvise or "make do" as the need arises. There are only two ways of performing salvage. One way is to remove the material outside the fire building or to an area that is not involved in the fire. This method is used when there is sufficient time and when there are enough people to carry out this duty or when there is only a small amount of material to protect. The other way is to protect the material where it stands. The second method is used when the size or the quantity of the contents of the building dictates. It would be impossible to clear a large warehouse, but a small office can be emptied in minutes with little confusion and with maximum security.

The amount of salvage work done at a fire depends on several factors, such as the amount of salvage equipment available, the personnel available, the type and amount of material involved, and the method of storage. Smoke and heat cause damage, but there is something else that can do more damage than the smoke, the heat, and the fire. This is water!

Protection against water damage. If you use a large amount of water in the extinguishing process, you can cause a large amount of damage. This is especially true if you are fighting a fire in housing, administrative buildings, warehouses, or stockrooms. Some of this damage is caused by the improper use of the water, such as using a straight stream instead of water fog, applying water when there is no fire, or applying the hose stream for a longer period than necessary. Most of the damage from water is done to material in storage, and results from poor storage practices over which you have no control during a fire. However, frequent inspections by the fire department can uncover such discrepancies beforehand. Correcting these will help you control the damage if a fire does occur. Some of the discrepancies are:

a. Material stored directly on the floor, where it soaks up water, instead of on pallets and skids.

b. Items stored in containers that weaken when wet.

c. Items on shelves or in bins arranged improperly against the walls, allowing water to run onto and into the stored material.

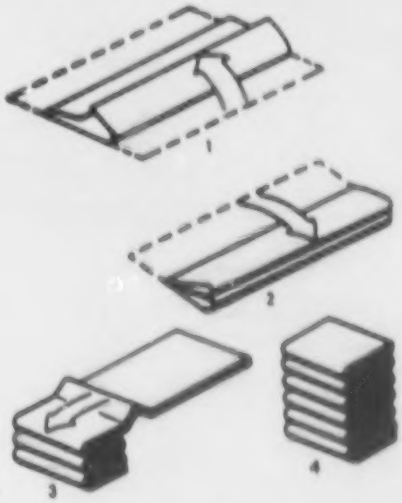

Figure 5-1. Accordion fold for small covers.

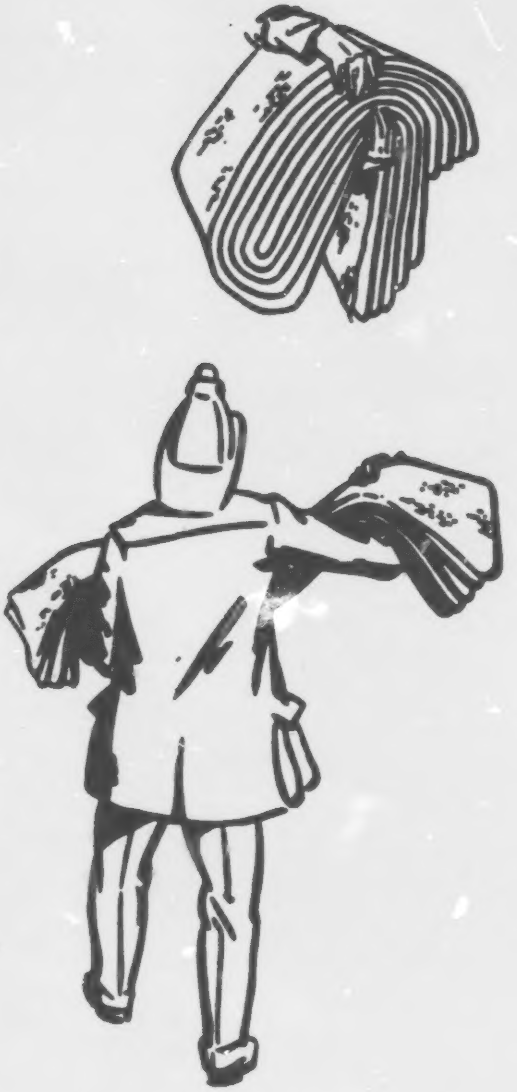

Figure 5-2. One-man cover throw.

To minimize water damage, use water to control and extinguish fire, but use it properly. You cannot wait until all the movable items are taken to a safe area because this would permit the fire to gain too much headway. Instead of waiting, there are alternative methods. Many fire departments carry common, inexpensive sawdust to help control the excess water. Sawdust can be used to absorb small quantities of water before damage has occurred. If there is too much water to absorb, you can pile the sawdust in dike form to keep the water localized or to channel it to the outside through doorways or other openings. One precaution — water has weight. A single 2½-inch line, with a 1⅛-inch nozzle at 50 psi nozzle pressure, delivers 265 gpm, which is more than a ton of water (1 ton = 239.9 gal). Sawdust itself has little weight, but when it absorbs and retains water, it can cause excessive stress on the structure. It may be necessary to drill or chop drainage holes in the floor to remove the accumulation of water. If these drainage holes are made with poor judgment of location, more damage can result than if no holes had been made.

Salvage covers. For stacks or piles of material (such as on Base Exchange display counters), warehouse-stored items, upholstered furniture, and unwieldly shop equipment, some fire departments use salvage covers. These covers are tarpaulins, known as "tarps." They are made of cotton canvas material treated with a waterproofing compound. There are usually only two sizes of standard covers used in the fire departments: small (12 by 18 feet) and large (14 by 18 feet).

When the 12-by-18-foot cover is folded correctly, one man can handle and manipulate it easily. It is kept folded in an accordion fold on the truck, ready for immediate use. As part of your training, you will learn to work with this cover. With practice, you will become proficient in "throwing it." Before you can "throw" the cover well, however, you should know the way it is folded. The steps are shown in figure 5-1. To fold, bring the long sides to the center (step 1); fold again (step 2); then, starting at one end of the folded cover, make 10-inch folds (step 3) and complete (step 4).

The "one-man throw," shown in figure 5-2, is a quick way to spread the small cover. Take the folded cover and place it over either forearm. With the cover in this position, grasp the bottom fold firmly with that hand; then reach in between your body and the cover with the other hand and take hold of the top three folds with your thumb down. Swing your arm up and over the shoulder, and throw as you would a shot-put. This will cause the cover to unfold and lie

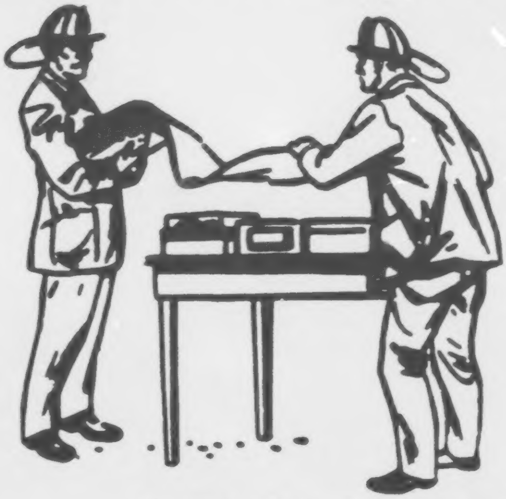

Figure 5-3. Counter payoff.

straight out. Then, quickly open the long folds and tuck the edges in at the bottom.

The counter payoff, shown in figure 5-3, is another method of spreading the cover. Two men are required for this one. One man holds the cover, the second man takes hold of the top fold and walks backwards. When the small folds are completely paid out, place the cover gently over the material to be protected and unfold the long folds. Again, when the cover is fully opened, tuck in the edges at the bottom.

The large cover requires two men to fold it because of its size and weight. To fold the cover (see fig. 5-4 for the steps), they position themselves at the corners of one of the longest sides (step 1). They fold the cover double (step 2), then redouble it (step 3). They bring the two ends together (step 4) and fold it again (step 5).

To carry the large cover, drap it over the shoulder of one man (1, fig. 5-5). Place the cover on the floor next to the area where it is needed. With each man holding two corners, they walk away from each other until the cover is fully extended except for the one remaining fold (2, fig. 5-5). Each man drops the edge of the cover closest to the material to be covered but holds on to the other edge. Together, they quickly

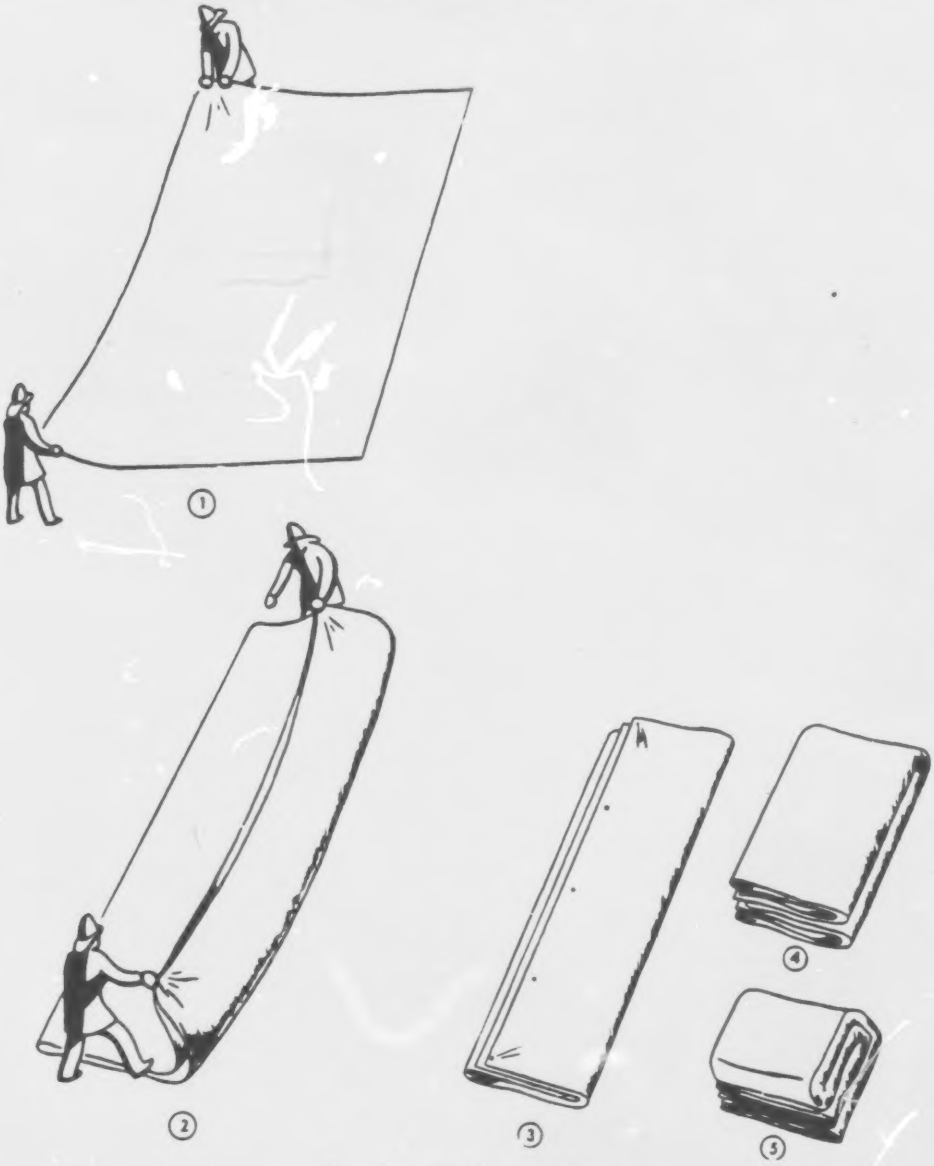

Figure 5–4. Fold for large covers.

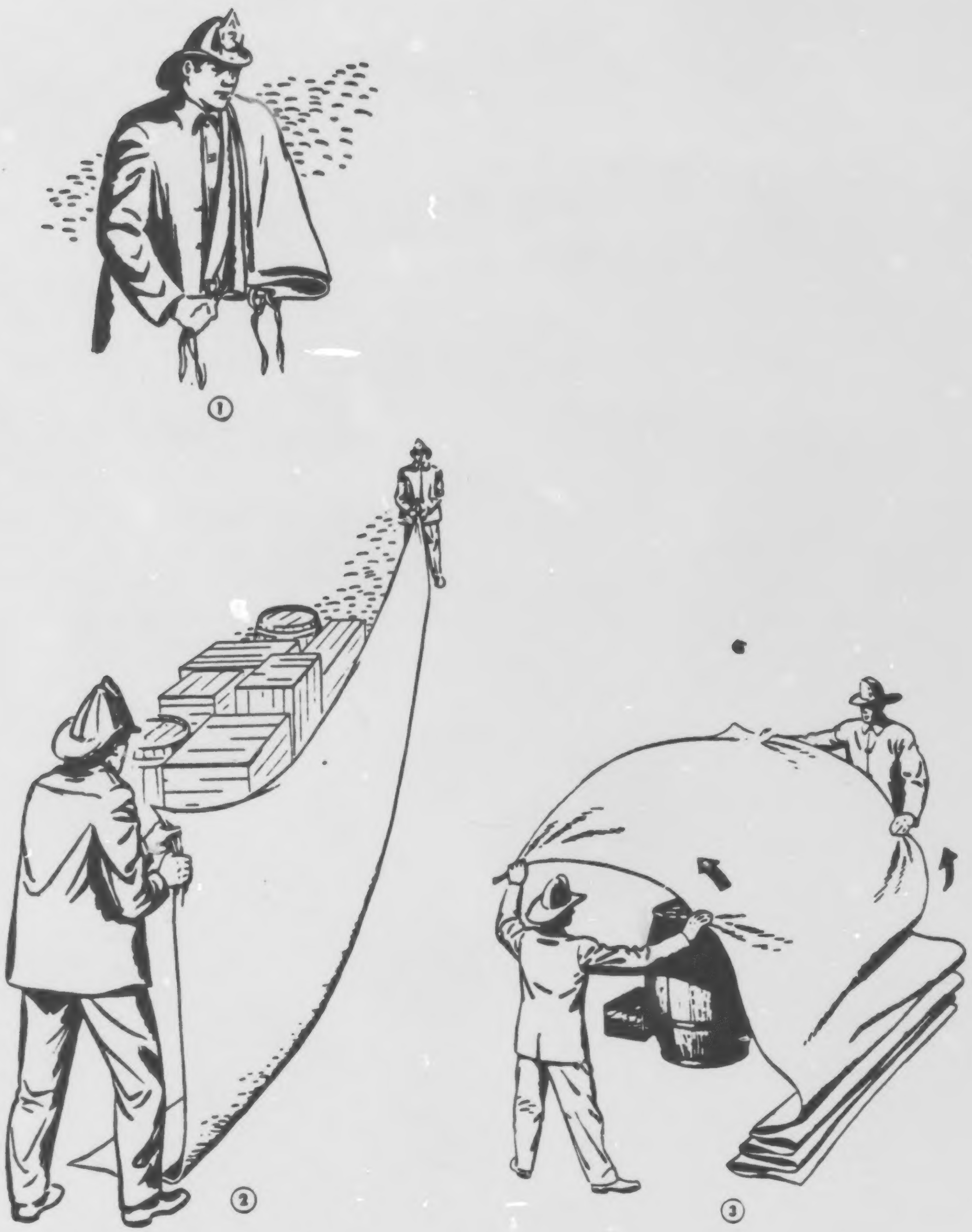

Figure 5–5. Spreading the large cover.

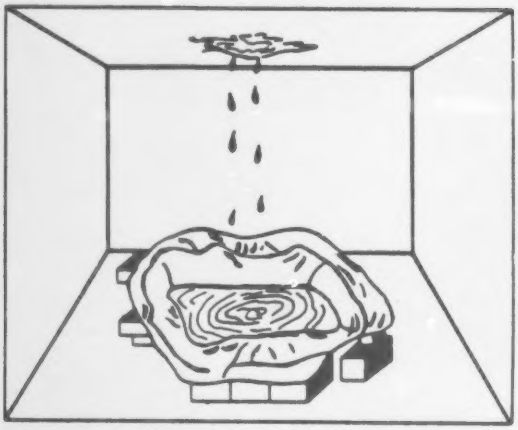

Figure 5–6. Salvage cover basin.

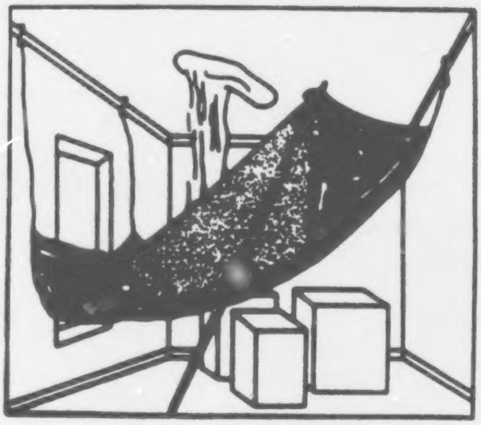

Figure 5–7. Window drain chute.

raise that edge and carry it over the material (3, fig. 5-5). The speed and coordination between the two men will cause the cover to "balloon," thus making it possible to place it properly. All corners and edges should be tucked in at the bottom.

Other protective devices. The contents and interiors of buildings may be severely damaged by water dripping through a floor or ceiling in which a drain cannot be made. To prevent this, improvised basins, such as the one shown in figure 5-6, are frequently needed to catch water which you can remove later by bailing, dumping, or pumping. You make a catch basin by placing furniture, boxes, or other equipment in a circle or square beneath the leak. Form a basin with the salvage cover by placing it over the furniture and boxes. Fasten the cover to the boxes and furniture or to the floor, with the bottom of the basin resting on the floor. If the quantity of water is not great, you can make shallow catch basins by rolling all four edges toward the center. The rolls form the sides of the basin.

You can use S-hooks, cord, salvage covers, and pike poles to build chutes that direct water through windows, thus protecting the contents and interiors of buildings from water damage. An example of this is shown in figure 5-7. Tie light rope or heavy cord through the grommets to support the covers. To protect material stored on shelves, cover the shelves with the salvage covers by using S-hooks, nails, and cord to suspend the covers from the walls and the ceiling, or by securing the cover with weights. If you need more than one cover, use lapovers of about 1 foot to prevent leakage.

To protect the interior structures and contents from water damage, stairway drains of canvas covers are frequently needed to direct water from upper floors to the outside, as shown in figure 5-8. There are two methods of forming stairway drains. Two men and two canvas covers are required to perform the operations efficiently. The first cover is spread by the one-man throw at the bottom of the stairs and fitted to the steps. The second cover is placed at the top of the steps in the same way, overlapping the lower cover about 1 foot.

In addition to the tarpaulin or salvage cover, the items most often used in salvage work are squeegees, brooms, buckets, pike poles, and sawdust. Shovels and buckets are used to remove debris. Water is removed from floors with squeegees, mops, buckets, and brooms.

When properly executed, salvage work can prevent almost as much property loss as the act of fire extinguishment itself. Practice the throwing, folding, and general handling of salvage covers under varied conditions until you are efficient enough to do the job without hesitation. For practice in a single coordinated motion by two men, the fire apparatus itself is an ideal object over which to throw the salvage covers. Set up catch basins in your salvage and pumper drills.

Exercises (A27):

1. State the two ways to perform salvage operations.

2. What factors determine the amount of salvage that can be performed?

3. Describe some of the improper uses of water that could cause water damage.

4. How can sawdust help to control water damage?

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5. State the sizes of salvage covers used in fire departments.

6. What type of fold is used on the small salvage cover?

7. How do you form a shallow catch basin?

8. What items do you need to form a drain chute through a window?

9. List the equipment most often used in salvage work.

A28. Describe selected overhaul procedures.

Overhaul. In our discussion of the supervisor's responsibilities in Chapter 4, we pointed out his duties during overhaul. Some of our discussion is repeated here. This operation involves a complete and detailed check of the structures and materials involved in the fire to make sure that every spark and ember has been extinguished and you have definite assurance against reignition.

Before overhaul is started, you must know whether or not the building will collapse because of

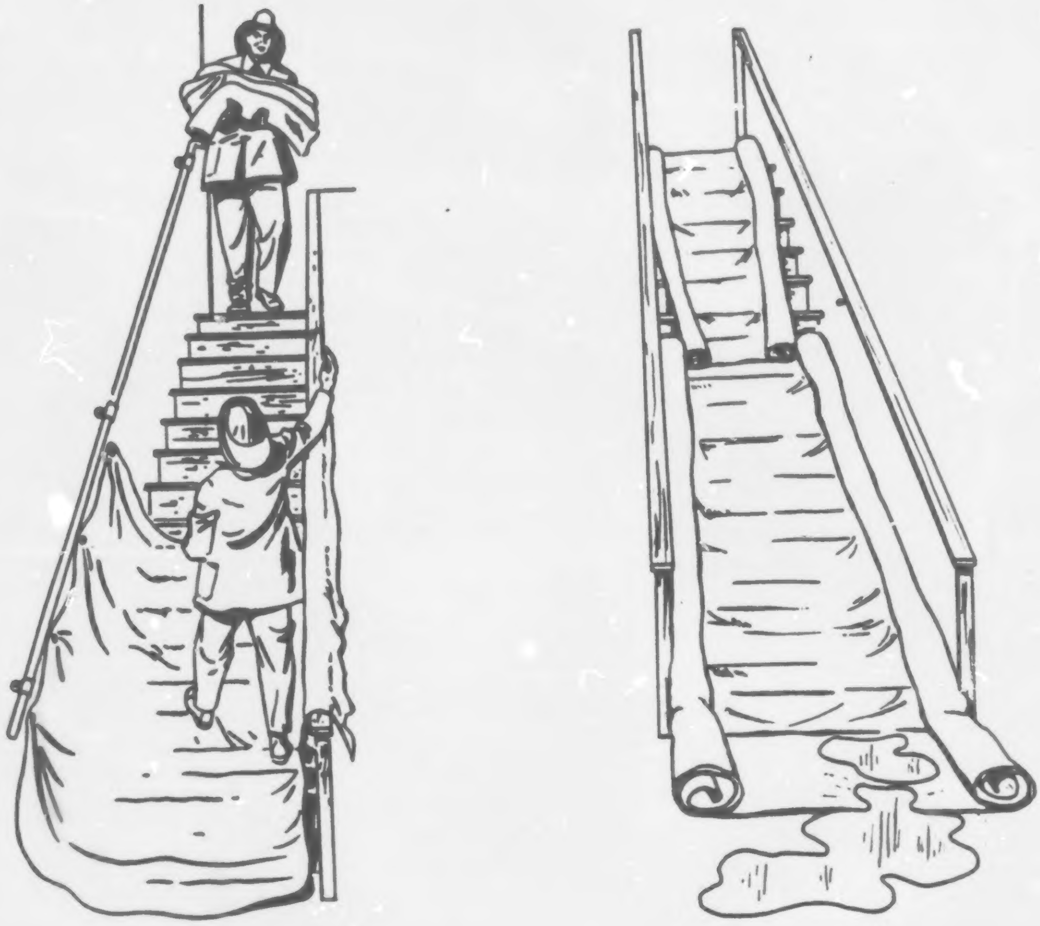

Figure 5–8. Stairway drain.

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structural damage and weakening. The supervisor usually makes this decision. Your job during overhaul is to make certain that the fire is fully extinguished.

Check the building for concealed spaces between the floor joists, ceiling beams, false or hanging ceilings, and walls and partitions. Check inside of cornices, inside of window and door casings, in light and air shafts, in pipe or wire recesses, and in chutes and vertical shafts where the fire can continue to burn unnoticed. As you move through an area, you can check for hotspots where fire may still remain by sliding the back of your hand over suspected surfaces. If you find a spot that feels warn or is blackened, *carefully* open up the suspected area and investigate.

When you are cutting inspection holes, make them as small as practical, square, and near studs, to avoid unnecessary damage and to simplify repair. When you are satisfied that there is no danger of reignition in the suspected area, check adjacent areas thoroughly, including attics, basements, walls, and adjoining rooms for possible fire spread.

Immerse glowing textiles, such as mattresses and clothing, in water. Remove smoldering piles of paper, rags, and similar materials to the outside and pull them apart in order to extinguish the deep-seated fire in the center. Recent developments in adding wetting agents or surface-active agents to water indicate the future possibility of more quickly and effectively extinguishing fires in materials that are not readily penetrated by plain water. These agents would make it unnecessary to tear apart and submerge each fragment in water.

Normally, surface fires involving lumber can be extinguished easily and quickly, but, because of the normal resistance of charcoal to water, heat and sparks can remain active for some time beneath the surface and deep within the lumber pile. In such places, a water solution containing a wetting agent can save time, damage, and energy.

Always be very careful in handling burned materials. Segregate cylinders, carboys, and other vessels containing gases and chemicals to prevent further damage and danger from explosion. Don't throw objects out of upper-story windows. If you must dump debris from upper floors, post someone below to warn others of the danger. Take particular caution when you are handling poisonous and corrosive substances. Separate burned materials from unburned objects, and place any undamaged goods where they will not be damaged during overhaul operations.

When your overhaul operation is finished, take precautions against subsequent injuries. Cover holes that were burned or cut in the flooring or block them off and block off approaches to damaged stairways and elevator shafts. Either pull down walls and chimneys that have been weakened seriously and endanger pedestrians or block off the area that they threaten.

Exercises (A28):

1. Describe an overhaul operation.

2. What must be done before the overhaul operations can begin?

3. Where in a building should you check for hot spots?

4. Describe the proper way to cut inspection holes.

5. When holes have been cut in floors, what should you do to guard against injuries to personnel?

A29. Point out precautionary steps in stabilizing a burned structure.

Structural Stability. It would be difficult to outline every operation that may be performed in the search for hidden fires. We will point out only certain fundamental conditions. We have already stated that, before the search for hidden fires, you must know the condition of the building in the area you will search. The intensity of the fire during the burning and the amount of water used in its control are two important factors that affect the condition of the building. The amount of water used determines the additional weight on the floors and walls because of their absorbent qualities. Considering these two factors carefully can prevent unnecessary loss of life during overhaul because of building collapse. A sagging roof means that its supports are weak. Sagging ceilings and floors tell you that there is damage to structural beams and supports. Large cracks in masonry walls show that they are weak. Firemen have been injured and killed from falling walls and ceilings that were weakened by fire. Weakened walls and building supports must be made safe before you make any attempt at overhaul. To repeat, pull down walls and chimneys that are weakened and are in a position to endanger personnel. Cover holes in the floors or block them off. Block off approaches to damaged stairways, stairwells, and elevator shafts. Brace weakened building supports if possible to assure safety to firemen during overhaul. If the gas and electricity have not already been turned off, turn them off.

Exercises (A29):

1. What does a sagging roof mean?

2. What must you do if a wall or chimney has been weakened to the point that it may collapse?

3. What must you do to approaches to damaged stairways, stairwells, and elevator shafts?

5-2. Preserving Evidence and Building Cleanup

In this section, we will describe basic attitudes and procedures in preserving evidence of arson and some steps in building cleanup. These two activities are more closely related than they may at first seem.

A30. Specify selected steps in preserving evidence.

Fires of INTENTIONAL origin can be caused, responded to, and extinguished without anyone noticing, reporting, or investigating. Fire department personnel must be able to recognize the evidence that is sometimes quite pronounced during and immediately after fires. Arson is a peculiar crime because there are usually no complaining witnesses to it. Arson is sometimes a result of careful planning and considerable preparation and sometimes it is committed on the spur of the moment. Since firefighters are normally not law enforcement officers, trained arson investigators are summoned to investigate suspected individuals and conditions. But firefighters are responsible for recognizing and preserving evidence of arson. Without this evidence, a trained investigator is always seriously handicapped. Firefighters can become proficient in recognizing and preserving evidence of arson and can organize the evidence in a sequence that will benefit the investigator when he arrives. Our purpose is to outline these activities.

Protecting and Preserving Material Evidence. The firefighter should keep two things clearly in mind about the protection and preservation of material evidence: (1) keep the evidence where you found it, untouched and undisturbed, if at all possible; and (2) when you discover evidence that you cannot leave it at the scene of the fire, properly identify it and remove and safeguard it. Make no changes of any kind in the evidence other than what is absolutely necessary in the extinguishment of the fire. Photographs are excellent supporting evidence if they are taken immediately.

One precaution to be taken by all firefighters during the fighting of a fire is avoid trampling over possible arson evidence and obliterating it so much that it is useless. Be careful in the use of water to avoid similar unsatisfactory results.

Guarding Evidence. You can protect the evidence remaining at the scene of the fire in various ways. You can rope off the area containing the evidence, or pile goods and materials of various kinds around the evidence to keep people away until the arrival of the investigator. Guards can be posted to prevent tampering with the evidence or handling it needlessly. Leave plenty of room around it to protect it exactly as you found it. For example, protect several feet of tire tracks, and if the car turned around, protect the print of all four wheels where the car turned. Detection work of this kind by firefighters makes it possible for trained investigators to take measurements and photographs later and to make plaster casts.

If you discover and protect several human footprints, the investigator can make measurements of the prints, compare the prints, and estimate the length of stride, the position of the feet, and any peculiarities in the gait (walk or run) of a suspect. He may also be able to secure identifying marks on the soles and heels of the shoes. Take similar precautions with animal footprints. Boxes placed over prints prevent dust from blowing over clear prints and keep them in good condition for photographs and plaster casts at a later time.

If you find burned and partially burned papers in a furnace, stove, or fireplace, protect them by immediately closing the dampers and other openings to eliminate or reduce the draft. You can use wet rags to smother the fire or to stuff stovepipes, but do not direct streams of water on such evidence.

Call the attention of the investigator to any grease that may have had a part in the fire. Bottles that were used to carry a flammable liquid sometimes carry latent fingerprints, although this possibility is not general because the prints are usually smudged by the liquid. But you are advised to protect all such bottles from indiscriminate handling, so that if such prints do exist, they can be identified. Sometimes bottles are filled with flammable liquids, tightly sealed, and hung over a set fire so that, when they reach a sufficient temperature, the bottles break and allow the liquid to increase the intensity of the fire.

Identifying and Removing Evidence. All evidence collected by firefighters should be properly identified, and preserved in clean containers. Make a careful notation of the date, the time, and the place where you found it. Additional identifying marks on cans, bottles, and other articles, such as the initials of the person who collected the evidence, may also be noted to establish unquestioned identity. Keep a record of witnesses and of each person who has had or will have responsibility for the care and preservation of the evidence.

When facilities for good paper and ash protection are not available, you can protect partly burned paper and ash between layers of plastic or between pieces of window glass for the investigator and for later transportation to a laboratory. If the fire was in a heating device where suspected paper evidence is located, remove the ashes and partially burned bits of paper by fanning them gently upon a clean glass plate. Keep this plate as near the paper and ash as possible. Flatten the ash and paper carefully with another plate of similar size and fasten them together. Now the investigator can take photographs without removing the burned material from the container.

Preserve letters, documents, and bills to assist in establishing a person's financial condition which might be a motive for arson.

Place wood suspected of containing paraffin or oil in a clear container and seal it until a chemical analysis can be made. Label all bottles with gummed stickers and identify them. Pack such objects as charred candlewick and burned matches in a bottle containing cotton to prevent breaking the evidence by jarring and handling. Store samples of materials, such as cotton, wood, rayon, felt, and other fabrics, in clean, large-mouthed bottles, seal them tightly and mark them properly. Put volatile liquids, oil samples, oil-soaked rags, waste, and the like in tin cans and seal them. This procedure will preserve odors as well as the materials themselves and the evidence can then be presented in court in its original condition. Any evidence of this sort should be sealed with wax, so that, if necessary, a laboratory technician can testify in court that the wax seal was unbroken until the proper time.

The firefighter who detects and finds evidence of arson should be able to identify it later. When such material has been properly marked, it is ready to be turned over to the proper authorities. Evidence should be kept under lock and key and as few persons as possible should be permitted to handle it. A record of each person who has handled the evidence should always be kept.

Exercises (A30):

1. Give two ways to protect material evidence.

2. Photographs are excellent supporting evidence if taken when?

3. In what ways can you protect evidence if you must leave it at the scene?

4. How should you protect the burned or partially burned papers you find in a furnace?

5. What should you do with all evidence collected?

6. Why should letters, documents, and bills be preserved?

7. How should you store volatile liquids, oil samples, oil-soaked rags, and waste?

A31. State the responsibility of fire department personnel in building cleanup and list the equipment used.

Building Cleanup. After a fire is extinguished, water and debris will remain. It is the responsibility of the fire protection personnel to remove them. You can scoop up nonsalvageable materials, such as plaster, rags, paper, and the like, into a carrier, carry them out of the building, and pile them in a conspicuous place for future examination. After most of the debris has been removed, you must mop up the excess water on the floors or use a squeegee. If the floor is wood, it is a good policy to take up the excess moisture by covering the floor with sawdust for a while and then clean it off. Do not leave damp sawdust on the floor longer than is absolutely necessary, for it can damage the floor. The equipment used in removing water and debris includes mops, brooms, squeegees, rags, rakes, shovels, and scoops.

Exercises (A31):

1. State the responsibility of fire department personnel in the cleanup operation.

2. If the floor is made of wood, what is a good method of getting up excess moisture?

3. List the equipment used in building cleanup.

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NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB, AL 36112, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs*. TOs, classified publications, and other types of publications are *not* available. Refer to current indexes for the latest revisions of and changes to the official publications listed in the Bibliography.

Note: Page Number 660 has been omitted.
However, all course material is included.

ANSWERS FOR EXERCISES

CHAPTER 1

References:

A01 - 1. Locate the fire, confine the fire, and extinguish the fire.
A01 - 2. Personnel, apparatus, equipment, water, and hose.
A01 - 3. Restricting the spread of the fire to the point of origin or at least to the area involved when the fire department arrives.
A01 - 4. Temperature, humidity, wind, and precipitation.
A01 - 5. Its location, accessibility, obstructions, exposures, and fire hydrants.
A01 - 6. Its extent and location in building, the building contents involved, life hazard, fire condition, and a possible need for respiratory protection, rescue equipment, or other special equipment.
A01 - 7. The type, age, condition, height, and area of the building; large unbroken areas, absence or presence of fire stops, channels of fire travel, and sprinklers.

A02 - 1. 2 27/32"; 3 1/2".
A02 - 2. Replace the rubber gasket when it becomes hard, grooved, or cut, and apply a light oil to moving parts.
A02 - 3. Neat's-foot oil.
A02 - 4. Paint it and apply a light coating of oil at any point of wear.
A02 - 5. Prying and closing gas cocks.
A02 - 6. Handle; hook.
A02 - 7. Cuts, scrapes, unraveling, and mildew.
A02 - 8. A light coating of boiled linseed oil.
A02 - 9. Paint may cover up signs of metal fatigue or corrosion, not allow the blade to cut fully, or cause it to stick.

A03 - 1. 3/4" × 100' manila hemp.
A03 - 2. Bind it tightly to prevent fraying.
A03 - 3. Half hitch.
A03 - 4. Square knot.
A03 - 5. Clove hitch, half hitch.

A04 - 1. Sounding.
A04 - 2. Joist.
A04 - 3. Never.
A04 - 4. Roof ladder.
A04 - 5. Pick axe.

A05 - 1. If you remove a few at a time, heat and smoke can keep you from finishing your job.
A05 - 2. With a jackhammer.
A05 - 3. Charged hoselines.
A05 - 4. Entering by the doors and windows.
A05 - 5. Wiring and pipes.
A05 - 6. During building inspections.
A05 - 7. Helmet, gloves, and eye protection.

A06 - 1. They may have been weakened or burned away to the point that the roof may collapse under your weight.
A06 - 2. Your back.
A06 - 3. Leeward, windward.
A06 - 4. Charged hose line.
A06 - 5. A draft caused by ventilating reduces the volume of smoke so that visibility is improved.

A07 - 1. The handles.
A07 - 2. Shut down.
A07 - 3. Near the blades.
A07 - 4. When you must rid the area of undesirable atmosphere to protect a human life.

CHAPTER 2

A08 - 1. Polyester fiber jacket and cotton jacket, rubber lined hose.
A08 - 2. Rubber-covered, rubber-lined wire-reinforced hose.
A08 - 3. In standpipe systems.

A09 - 1. To join two female hose connections.
A09 - 2. The solid (nonswivel) portion.
A09 - 3. Siamese.
A09 - 4. Wye.
A09 - 5. The playpipe, shutoff valve, and tip.
A09 - 6. Has a wide range of uses, and reduces water damage.

A10 - 1. The cap nearest the fire.
A10 - 2. When the truck stops at the fire.
A10 - 3. REVERSE LAY.
A20 - 4. Driver and plugman.

A11 - 1. The right shoulder.
A11 - 2. 10 to 12 feet apart.
A11 - 3. The underarm carry.
A11 - 4. To prevent damage to the nozzle.

A12 - 1. Kinking the hose or applying a hose clamp.
A12 - 2. 25 feet.
A12 - 3. 10 feet.
A12 - 4. Shut off the nozzle and make a loop in the hose. Then tie the nozzle slightly ahead of the loop.

A13 - 1. When the distance between the water source and the point where the water is used is so great that it requires too much pressure for a single pumper.
A13 - 2. 200 psi.
A13 - 3. To bleed the air from the lines between the pumpers.
A13 - 4. The pumper with the smallest pump capacity.
A13 - 5. Divide the required nozzle pressure by the friction loss per 100 feet of 2½-inch hose
A13 - 6. Divide the sum total length of the imaginary line and the actual hose lay by two.

A14 - 1. Right front.
A14 - 2. Front; rear.
A14 - 3. Three inches; the folds will be less sharp and you can put more hose in a layer.
A14 - 4. A baffel board.
A14 - 5. Dutchman.

A15 - 1. Straight lay.
A15 - 2. 100 feet.
A15 - 3. 150.
A15 - 4. You take two 150-foot sections of 1½-inch hose, connect them to the wye and add the nozzles to the 1½-inch hose.

A16 - 1. It may result in cuts, abrasions, punctures to the hose, and damaged couplings, threads, and lugs.
A16 - 2. A baking soda solution to counteract the acid.
A16 - 3. Paint will deteriorate the hose and striking a metal stamp too hard can damage the coupling.
A16 - 4. In a clean, dry, well-ventilated place away from heat and bright light. Heat and light can ruin rubber and moisture causes mildew.

A16 - 5. Use a hose bridge.
A16 - 6. Scrub with a mild soap and water and flush the soap with clear water.
A16 - 7. To prevent mildew.

A17 - 1. Daily, after each use, monthly, quarterly, and annually.
A17 - 2. The removal, inspection, and reloading.
A17 - 3. With a hand pump.
A17 - 4. Every 10 years.
A17 - 5. Three hundred feet.
A17 - 6. Five minutes.

CHAPTER 3

A18 - 1. The bed ladder.
A18 - 2. Halyard.
A18 - 3. 14 feet.
A18 - 4. Roof ladder.
A18 - 5. 26, 35 or 36 feet.

A19 - 1. The hooks or top is carried forward and tilted slightly down.
A19 - 2. Place your shoulder at the center of the extension ladder with the heel of the ladder forward.
A19 - 3. A minimum of two men.
A19 - 4. The lead man can use his outside hand to prevent injury to persons in the line of travel.
A19 - 5. On the ground with the fly(s) up.

A20 - 1. Divide the length of ladder by 4.
A20 - 2. Lock the pawls or dogs.
A20 - 3. "Walks" the ladder up to the building by using the rungs of the ladder.
A20 - 4. In the three-man raise, you have two men "walking" the ladder up by the beams instead of one man by the rungs.
A20 - 5. Turn the ladder so that the fly is not between the building and the ladder bed.

A21 - 1. When you are carrying equipment.
A21 - 2. Twice.
A21 - 3. To prevent the ladder from wobbling.
A21 - 4. Lock you foot either around the rung or around the beam of the ladder.

CHAPTER 4

A22 - 1. When responding in the housing areas where there is a danger of children running in front of you.
A22 - 2. Turn on your beacon light and honk the horn to warn others that you are backing.
A22 - 3. As close to the fire as safety and convenience permit.
A22 - 4. The noncollapsible hard suction hose.
A22 - 5. As close to the water supply as safety permits.
A22 - 6. 10 to 12 feet.
A22 - 7. With the pump intake a few feet short of the hydrant outlet.

A23 - 1. Planning, visualizing, preparing size-up and layout.
A23 - 2. When the first crew comes in contact with the fire.
A23 - 3. The incipient phase, the free-burning phase, and the smoldering phase.
A23 - 4. When it has extended beyond the confining wall of a room or building.
A23 - 5. Direct method and indirect method.
A23 - 6. Solid stream and fog stream.
A23 - 7. Use fog streams from small hose lines.
A23 - 8. Conduction, radiation, convection, and flame contact.
A23 - 9. The transfer of heat by moving air currents.
A23 - 10. Where the most intense burning is present.

A24 - 1. Preventing fire from extending to uninvolved areas.
A24 - 2. Water streams, other extinguishing agents, and ventilation.
A24 - 3. To maintain an adequate supply of water to the sprinklers.
A24 - 4. Performing salvage cover operations and routing water from a building.

A25 - 1. Suppressing flame with an extinguishing agent and any other operations required to stop burning action.
A25 - 2. A high heat-absorbing capacity by volume, practical, and economical.
A25 - 3. Water must be converted into steam.
A25 - 4. (1) To quench the main body of the fire, (2) to extinguish spot and area fires.

A26 - 1. The supervisor must decide whether or not the building will collapse because of structural damage and weakening caused by the fire.
A26 - 2. Electrical shock and explosion if gas lines are ruptured.
A26 - 3. Sleeping, awake, injured, bedfast, and immobilized.
A26 - 4. Using ladders, elevating platforms, carries, drags, ropework, stretcher work, life net, and lifeline.
A26 - 5. By radiated heat, direct flame contact, or flying brands.
A26 - 6. The existing distance between buildings.

CHAPTER 5

A27 - 1. Remove the material to the outside or to an area not involved by fire and protect the material where it stands.
A27 - 2. The amount of salvage equipment, the number of personnel available, the type and amount of material involved, and the method of storage.
A27 - 3. Using a straight stream instead of water fog, applying water where there is no fire, or applying a hose stream for longer periods of time than required.
A27 - 4. Sawdust can be used to absorb small quantities of water or can be piled in a dike form if there is too much water to be absorbed.
A27 - 5. Small is 12 feet by 18 feet and the large is 14 feet by 18 feet.
A27 - 6. The accordion fold.
A27 - 7. Roll all four edges toward the center to form the sides.
A27 - 8. S-hooks, cord or rope, salvage covers, and pike poles.
A27 - 9. Salvage covers, squeegees, broom, buckets, pike poles, and sawdust.

A28 - 1. A detailed check of the structure and materials involved in the fire to insure the complete extinguishment of fire.
A28 - 2. The possibility of building collapse must be determined.
A28 - 3. Concealed spaces between floor joists, ceiling beams, false ceiling, walls and partitions, inside of cornices, inside of window and door casings, light and air shafts, pipe and wire recesses, chutes, and vertical shafts.
A28 - 4. Cut small square holes near the studs.
A28 - 5. You should either block off the hole or cover it.

A29 - 1. The roof supports are weak.
A29 - 2. Pull down the wall or chimney.
A29 - 3. Block them off.

A30 - 1. (1) Leave the evidence where it is found, untouched and undisturbed; (2) properly identify, remove, and safeguard it.
A30 - 2. Immediately.
A30 - 3. Rope off the area, pile materials around the evidence, or post guards around the evidence.

A30 - 4. Close the damper or use a wet rag to smother the fire or stuff stove pipes.
A30 - 5. Identify it and preserve it in clean containers.
A30 - 6. To establish a person's financial condition, which might indicate a motive for arson.
A30 - 7. Sealed in tin cans.

A31 - 1. Remove water and debris.
A31 - 2. Cover the floor with sawdust; then clean up the damp sawdust.
A31 - 3. Mops, brooms, squeegees, rags, rakes, shovels, and scoops.

NOTE: Page Number 664 has been omitted.
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STOP -

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

57150 06 21

STRUCTURAL FIREFIGHTING

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

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Multiple Choice

1. (A01) The first step in firefighting strategy is to

   a. rescue personnel.
   b. extinguish the fire.
   c. confine the fire.
   d. locate the fire.

2. (A01) Confining a fire means holding the fire to

   a. one room in a building.
   b. one floor in a building.
   c. the building itself.
   d. all of the above.

3. (A01) The time of day can have a direct bearing on firefighting operations for all of the following reasons except the

   a. speed of the response of firefighting and rescue vehicles.
   b. life and fire hazards involved.
   c. amount of apparatus available for response.
   d. number of personnel available for response.

4. (A01) What are two types of exposures you must be concerned with upon arrival at the scene of a building fire?

   a. Weather exposure and life exposure.
   b. Materials exposure and time exposure.
   c. Life exposure and fire exposure.
   d. Time exposure and weather exposure.

5. (A02) The universal thread adapter has how many jaws to lock onto male hose threads?

   a. 2.
   b. 3.
   c. 4.
   d. 6.

6. (A02) To prevent a serious decrease in the length of a hose line, the hose clamp should be placed approximately how far from a coupling?

   a. 10 feet.
   b. 6 feet.
   c. 3 feet.
   d. 1 foot.

7. (A02) Which of the following hose tools is generally carried in a pocket of your firefighting clothing before its use?

   a. Hose strap.
   b. Hose clamp.
   c. Hose jacket.
   d. Universal thread adapter.

8. (A02) When, if ever, should wooden-handled tools have their handles sanded?

   a. Whenever a roughness develops.
   b. Before a coating of shellac.
   c. After each use or every 30 days whichever comes first.
   d. Never.

9. (A03) Ropes used for hoisting and anchoring by Air Force fire departments are of what diameter?

   a. 3/4 inch.
   b. 5/8 inch.
   c. 1/2 inch.
   d. 3/8 inch.

10. (A03) Which of the following is used as a safety measure in conjunction with other knots and hitches?

    a. Clove hitch.
    b. Half hitch.
    c. Sheepshank.
    d. Becket bend.

11. (A03) To strengthen the position of a charged hose line on a ladder, you should use a

    a. bowline.
    b. square knot.
    c. chimney hitch.
    d. becket bend.

12. (A03) Which of the following knots should be used to form a secure loop in a length of rope?

    a. Square knot.
    b. Chimney hitch.
    c. Becket bend.
    d. Bowline.

13. (A04) The best way for firefighters to determine the material from which roofs are constructed is through

    a. inspection surveys.
    b. plans and drawings of the facility.
    c. contract specifications.
    d. actual opening in the roofs.

14. (A04) Which of the following factors would you not use in determining the location for the opening to be made in a wood joist or rafter roof for ventilation?

    a. Highest point on roof.
    b. Distance between joist or rafters.
    c. Existing exposures.
    d. Extent of fire.

15. (A04) Which of the following types of roofs would be difficult and dangerous to open for ventilation?

    a. Flat.
    b. Gable.
    c. Arched.
    d. Pitched.

16. (A05) When opening a finished wooden floor, there are how many separate cutting jobs required?

    a. 2.
    b. 3.
    c. 4.
    d. 6.

17. (A05) When discussing "breaching" operations in firefighting, you are discussing

    a. emergency childbirth.
    b. cleaning fire pump components.
    c. cutting through a multi-layered roof.
    d. opening a masonry wall.

18. (A05) If you must cut furring strips to provide for ventilation during a firefighting operation, you would be opening a

    a. concrete floor.
    b. dropped ceiling.
    c. masonry partition.
    d. metal exterior wall.

19. (A06) Which of the following locations is the least desirable for making an opening for the ventilation of a fire?

    a. Below the level of the fire.
    b. Above the level of the fire.
    c. Leeward side of the fire on the same level.
    d. Windward side of the fire on the same level.

20. (A07) Electric forced air blowers should be equipped with which of the following?

    a. Damper switches.
    b. Explosion-proof motors and power cable connections.
    c. 16-gage, three-strand solid copper wire power cords.
    d. Smoke-and-dust proof connectors and power cable.

21. (A08) Polyester-fiber-jacket hose normally is supplied in all the following sizes except

    a. 4 1/2 inches.
    b. 2 1/2 inches.
    c. 1 1/2 inches.
    d. 1 inch.

22. (A08) Which of the following types of hose is the least flexible?

    a. Polyester fiber jacket.
    b. Cotton-jacket, rubber lined.
    c. Rubber-covered, wire-reinforced.
    d. Unlined linen.

23. (A09) If you pick up a hose connection with two sets of male threads and one set of female threads, you will be holding a

    a. wye.
    b. siamese.
    c. tailpiece or bow.
    d. universal reducer.

24. (A10) The small loss of time suffered in making a reverse lay is more than compensated for by the assurance of which of the following?

    a. A constant 750 gpm flow.
    b. A consistent pressure from the pumper.
    c. The increased amount of working line at the fire scene.
    d. The availability of manpower and equipment at the fire itself.

25. (A11) When advancing an empty hose line up a ladder, personnel should climb about how many feet apart?

    a. 27-30.
    b. 22-25.
    c. 15-20.
    d. 10-12.

26. (A11) Under most conditions, which of the following techniques is considered superior for advancing an empty hose up a stairway?

    a. The over the shoulder carry.
    b. The backpack doughnut carry.
    c. The over the arms (baby) carry.
    d. The underarm carry.

27. (A12) Should the fifth section of hose in a nine-section lay rupture and require replacement, how many sections of hose should there be in the lay after replacement is made to insure adequate working line?

    a. 11.
    b. 10.
    c. 9.
    d. 8.

28. (A13) When making a relay using three pumpers with capacities of 1000 gpm, 750 gpm, and 500 gpm, they should be placed in what sequence from the source of water to the fire?

a. Source, 1,000 gpm, then 750 gpm, and 500 gpm near fire.
b. Source, 500 gpm, then 750 gpm, and 1,000 gpm near fire.
c. Source, 750 gpm, then 1,000 gpm, and 500 gpm near the fire.
d. Source, 1,000 gpm, then 500 gpm, and 750 gpm near fire.

29. (A13) Pumpers within a relay usually should not operate above a discharge pressure of

a. 275 psi.
b. 250 psi.
c. 225 psi.
d. 200 psi.

30. (A14) When making a standard horseshoe load, the coupling should be placed in what location to start the load?

a. Left rear corner of the bed.
b. Right rear corner of the bed.
c. Right front corner of the bed.
d. Left front corner of the bed.

31. (A14) One single long lay can be made from a divided hose load loaded for a double reverse by connecting the

a. two male ends with a double female connection.
b. two female ends with a double male connection.
c. lower left male connection with the lower right female coupling.
d. upper left male coupling with the lower right female coupling.

32. (A15) The doughnut roll finish is used with what type of hose load?

a. Horseshoe.
b. Accordion.
c. Divided.
d. All of the above.

33. (A15) When making a skid-load finish, how much clearance should there be on each side of the crosswise ripraps and the hosebed walls?

a. 1 1/2 inches.
b. 2 or 3 inches.
c. 4 to 5 inches.
d. None.

34. ((A16) What effect, if any, do petroleum products have on cotton jacket firehose?

a. None.
b. They dissolve the jacket.
c. They loosen the cement attaching the coupling.
d. They cause the lining to tear apart and pile up in the hose.

35. (A16) When marking the jacket of a firehose, you should use

a. latex paint.
b. lacquer paint.
c. enamel paint.
d. indelible ink.

36. (A16) Why should the water be drained from the firehose before it is stored?

a. The added weight of the water may damage the hose rack.
b. When water is left in a hose, it makes the rolls larger and they require more space for storage.
c. Water left in the hose tends to absorb sulfer from the inner lining and form a sulfuric acid solution.
d. The hydrochloric acid formed by the reaction between the rubber lining and water is highly toxic when in an enclosed area.

37. (A17) How often should unlined standpipe hose be tested?

a. Annually.
b. Every 5 years.
c. Every 10 years.
d. Testing is not performed.

38. (A17) Which of the following statements best describes the hydrostatic testing of 1 1/2-inch multi-jacketed, cotton-and-polyester covered rubber lined fire hose?

a. Maintain 250 psi on the hose for 5 minutes.
b. Maintain 150 psi on the hose for 3 minutes.
c. Maintain maximum pump pressure on the hose for 1 minute, then reduce pressure to 250 psi for 4 minutes.
d. Test at a pressure 50 percent greater than the highest pressure encountered during the past year for three minutes.

39. (A18) What is a fly ladder?

a. The top sections of an extension ladder.
b. A lightweight ladder that folds for easy use in close quarters.
c. A ladder similar to a roof ladder except for the oversized hook which enables it to used for scaling walls.
d. There is no such thing as a "fly ladder."

40. (A18) The most common size straight ladder used by Air Force firefighters is

a. 12 feet long.
b. 14 feet long.
c. 16 feet long.
d. 24 feet long.

41. (A19) When one person is carrying a roof ladder, in what position should the hooks be?

a. Forward and elevated.
b. Rearward and elevated.
c. Forward and lowered.
d. Rearward and lowered.

42. (A19) What is the minimum number of personnel required to remove a 35-foot extension ladder from a truck?

a. 2.
b. 3.
c. 4.
d. 5.

43. (A20) To determine how far to place the heel of a ladder from the building, you should

a. divide the height of the building by 5 and add 2 to determine the number of feet.
b. divide the length of the ladder by 2 and add 5 to determine the number of feet.
c. divide the length of the ladder by 5 and add 2 to determine the number of feet.
d. extend the ladder to its full length and tie the rope on the fourth ring from the bottom and set the ladder so that the rope contacts the ground at a 90° angle.

44. (A20) Normally, raising a 36-foot extension ladder requires at least how many personnel?

a. 2.
b. 3.
c. 4.
d. 5.

45. (A21) If the rungs on a ladder were numbered from 1 through 36 and you are starting to climb up with your left hand on rung 5, the next rung you should grasp with your left hand would be rung number

a. 7.
b. 8.
c. 9.
d. 10.

46. (A21) When climbing a ladder covered with ice, how should the feet be placed on the rungs?

a. The arch of the foot should be placed in the center of the rung.
b. The ball of the foot should be placed in the center of the rung.
c. The arch of the foot should be on the rung with the instep against the beam.
d. The heel of the boot should be on the outer most part of the rung next to the beam.

47. (A21) When should you anchor yourself to a ladder with a hose rope or safety belt?

a. Never.
b. Only when the ladder is covered with ice.
c. Only when the nozzle pressure will exceed 50 psi.
d. When you must maintain one position for a long time.

48. (A22) In which of the following situations would it be best not to use the audiowarning devices on a firefighting vehicle while responding to an emergency?

a. While crossing the flightline enroute to one of the taxiways.
b. When approaching an intersection within 200 feet of a hospital.
c. While passing through housing areas and residential areas.
d. Upon entry to a highway on a mutual aid run.

49. (A22) What percent of the time should the safety belts be used on fire protection vehicles?

a. 100.
b. 85.
c. 66.
d. 50.

50. (A22) When spotting a pumper for drafting during firefighting operations, the vehicle should be positioned so that a lift not to exceed how many feet may be made?

a. 10 to 12.
b. 15 to 17.
c. 23 to 25.
d. 31 to 33.

51. (A23) Which of the following knowledges is most essential to a supervisor when determining an attack on a fire?

a. Avenues of fire spread.
b. The type of fire.
c. Agent application techniques.
d. The point of fire origin.

52. (A23) Which of the following factors is not considered important to water application for fire extinguishment?

a. Selecting points from which streams may be operated.
b. The choice of fire streams and distribution.
c. The rate of application of water.
d. Temperature of water being applied.

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53. (A23) The spread of fire by which of the following methods probably has more influence upon the positioning for fire attack than the other three?

a. Conduction.
b. Convection.
c. Radiation.
d. Flame contact.

54. (A24) When is confinement of a fire not possible?

a. As long as the action against the fire is offensive.
b. When the spread of fire to uninvolved areas is stopped.
c. During that short period of time between the control of the fire and when extinguishment begins.
d. As long as the action against the fire is defensive.

55. (A24) Which of the following utility valves should be left open or on during the confinement phase of a firefighting operation?

a. Gas lines.
b. Electric power lines.
c. Domestic water supplies.
d. Water supplies to private protection devices.

56. (A25) How to apply the extinguishing agent on a fire depends upon the form of the extinguishing agent and the

a. physical arrangement of the fuel.
b. amount of agent available after confinement.
c. number of personnel trained in the use of the type agent being used.
d. amount of time that can be used in the application.

57. (A25) What is the first step toward the final extinguishment of a fire?

a. Determining the point of origin of the fire.
b. "Mop up" of any and all spot fires.
c. To quench the main body of the fire.
d. Locate and control any "hidden" fires.

58. (A26) How should a wall be checked for "hot spots"?

a. By feeling the wall with the palm of your hand.
b. By feeling the wall with the back of your hand.
c. By removing the covering from the entire wall.
d. By cutting rectangular inspection holes through two or more wall studs.

59. (A26) Which of the following factors would have the least influence to regulate the type and priority of rescue that may be needed in a structural fire situation?

a. The physical condition of the occupants.
b. The mental condition of the occupants.
c. The size of the building occupants.
d. The number/location of the building occupants.

60. (A27) How many ways are there of performing salvage?

a. 2.
b. 4.
c. 7.
d. There is no set number of ways, the limits are set by the imagination of the individual directing the operation.

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61. (A27) Which of the following causes the most damage during a fire?

a. The heat.
b. The water.
c. The smoke.
d. The fire itself.

62. (A27) What are the two standard sized salvage covers used by Air Force fire departments?

a. 10 x 14 feet and 12 x 16 feet.
b. 12 x 14 feet and 14 x 16 feet.
c. 12 x 18 feet and 14 x 18 feet.
d. 16 x 20 feet and 18 x 22 feet.

63. (A27) How is a stairway drain made using salvage covers?

a. The first cover is placed at the top of the stairway and spread downward with the second cover placed over the first with at least a 1-foot overlap.
b. The two covers are laid out flat and the overlap seam folded and the sides rolled to fit the stairway, then slid into place.
c. The first cover is placed at the bottom of the stairs and played out and fitted up the stairs. The second cover is then placed at the top of the stairs and played out and fitted down the stairs same manner with about 1 foot of overlap.
d. The first cover is extended downward from the center of the stairway with the second cover placed at either the top or bottom as the need arises, and extended its maximum length. The center overlap is rolled or pinned for at least 1 foot.

64. (A28) When is an overhaul operation complete?

a. When all spot fires have been extinguished.
b. After the building has been found structurally sound.
c. After all the fiber-type materials have been wet down with a wetting agent.
d. When every spark and ember has been extinguished and you have definite assurance against reignition.

65. (A28) A "wetting agent" would not normally be used during the overhaul of which of the following fires?

a. A fire in the CE lumber yard.
b. A fire in the clothing sales store.
c. A fire in a POL bulk storage tank.
d. A fire in the heating plant coal pile.

66. (A29) What are the two more important factors to be considered when determining the structural stability of a fire building before overhaul is begun?

a. The number of personnel required for overhaul and the part of the building in which overhaul is to be performed.
b. The intensity of the fire during burning and the amount of water used during control and extinguishment.
c. The degree of list in the walls or sag of the roof, and the age and type of building materials used in the initial construction.
d. The amount of damage caused by cracking and spauling of concrete components and the length of the expansion of metal structural members.

67. (A30) Which of the following information cannot be determined by protecting and comparing human footprints found at the scene of a fire where arson is suspected?

a. The length of the stride.
b. The position of the feet.
c. Any peculiarities in the gait.
d. The individual's sex and age.

68. (A30) Why should letters, documents, or bills demanding payment be preserved in cases where the cause of the fire is suspect?

 a. To aid insurance companies in making proper payments.
 b. So the property owners will have a record of monies owed and to whom it is owed.
 c. To assist in establishing a person's financial condition which might indicate a motive for arson.
 d. So emergency relief agencies will know who to contact for a deferment of payment on the property owner's behalf.

69. (A31) How long should damp sawdust be left on a wooden floor during clean-up operations?

 a. At least 30 minutes.
 b. No longer than one hour.
 c. Until all other clean-up is completed.
 d. No longer than absolutely necessary.

70. (A31) Who is responsible for the removal of debris and nonsalvageable material after a fire?

 a. Fire protection personnel.
 b. The warehouse workers.
 c. Base supply personnel.
 d. Personnel from the organization to which the material was assigned.

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CDC 57150

FIRE PROTECTION SPECIALIST

(AFSC 57150)

Volume 7

Aerospace Vehicle Firefighting

Extension Course Institute

Air University

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

IN THIS FINAL volume of CDC 57150, you will learn about aerospace vehicle firefighting (or in the language of the field "Aircraft Crash Firefighting"). You will study the principles of aircraft firefighting, standby and patrol, command and control, salvage and overhaul, and training and duty levels.

Code numbers appearing on figures are for preparing agency identification only.

Please note that in this volume we are using the singular pronoun *he*, *his*, and *him* in its generic sense, not its masculine sense. The word to which it refers is person.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTGOX, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education office, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 9 hours (3 points).

Material in this volume is technically accurate, adequate, and current as of July 1979.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Principles of Aircraft Firefighting

THE PRINCIPLES of fighting aircraft fires are the same regardless of the type of aircraft, though since some types are larger than other, they require more equipment and more manpower.

Sometimes the control tower furnishes you the information regarding the type of aircraft, personnel on board, fuel, cargo, etc. Sometimes it does not. When trouble comes, you must be able to recognize the aircraft while it is in flight, and try to determine, by its flight characteristics, what its difficulties are. Particular emphasis should be placed on the type of aircraft predominant at your base. This is the beginning of aircraft recognition.

A good way to improve your aircraft recognition is by studying films, technical orders, etc. Make every effort to inspect different types of aircraft. Remember that 70 percent of all aircraft accidents occur on or near an airstrip. You must know the landing and takeoff patterns so that you can spot an aircraft that is straying out of pattern—thus indicating that it is in trouble.

Knowing how runways are numbered is a great help when you are transferred from one base to another. You should know, for instance, that an aircraft coming in for a landing on "runway nine" is coming in from the west and is headed east.

Off-base crashes are serious problems to all crash-rescue crews. Sometimes an off-base crash is very difficult to locate and just as difficult to reach, requiring the combined use of grid maps, radio, and aircraft.

Part of your training should be familiarization with the surrounding area. If a crash occurs off-base, you should know the shortest route and the condition of the roads, bridges, etc., to the scene. Sometimes improving these areas makes it easier to reach a downed aircraft when an emergency does occur.

Whether an emergency occurs on base or off base, you can always be prepared to meet the situation by preplanning your actions and by being always alert.

1-1 Teamwork

Teamwork is important in all firefighting activities, but in crash firefighting and rescue, where time is a definite factor, success depends entirely upon teamwork because of the many activities that must be carried on simultaneously. Swift, complete, and automatic cooperation is a vital necessity. Spectacular efforts of an aggressive few cannot produce the results of a well-trained, cooperative team. Individualism is out.

CO1. Point out the importance of teamwork in aircraft firefighting operations and selected operational details, and list the members of the team.

Teamwork starts with the attitude of the individual. If he is a grandstand player, then he is in the wrong field of endeavor. He must be taught that he is only a part, though an important part, of a very important team. From the individual, teamwork extends to the single firefighting crew, to other firefighting crews, and to all activities that contribute to the operation, not as individual units but as component parts of an overall plan, each with a full knowledge of the objectives of all other participants. This teamwork must never be relaxed.

When the firefighting crews arrive at the

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scene of the emergency, they must know all about the aircraft involved in order to plan an intelligent attack. The tower operator, as a part of the team, furnishes much of this information through radio contact with the firefighting vehicles. (Valuable information may be obtained from aircrew members who have escaped from the aircraft.) The tower operator should supply the following information:

- The type of aircraft involved. (This will indicate structural problems.)
- The number of personnel on board. (This will indicate the extent of rescue operations.)
- The nature of the emergency. (This may govern the firefighting tactics.)
- The approximate quantity of fuel remaining in the tanks, the type and amount of cargo, ammunition, and bombs, and any other contents of the aircraft that are dangerous to fire protection personnel.

At flight training schools and other bases, most of the flying activities are routine local flights. Normally, base operations can, through the tower operator, furnish all information desired if it knows the serial number of the aircraft concerned.

To develop precision teamwork, firefighting crew members should be assigned definite duties and responsibilities. However, they must be trained in the duties of all positions, and the assignments must be flexible enough to allow for unexpected events. A crew member may be assigned as crew chief, driver, equipment (turret) operator, handline or rescue team member. But the circumstances of the emergency may require that the crew chief effect the rescue, that the driver double as a driver and equipment (turret) operator, or that the equipment (turret) operator assist the handlineman. The interchange of crew positions during the actual operation should be a natural action and not necessarily dependent upon orders from the person in charge.

Every unit in an operation should be under the direction of a responsible crew chief. If a single unit is operating unaided at an aircraft accident, the crew chief of that unit is in charge. If two or more units coordinate in an operation, each unit, of course, has its own crew chief, but the crew chief of the first unit to arrive at the scene is in overall charge until the arrival of the fire chief or assistant chief. Thus, the responsibilities of the first arriving crew chief are many and exacting, for the initial plan of attack is, in many cases, the deciding factor between the success or failure of the operation.

Each piece of auxiliary equipment, such as water tankers and wreckers, is manned by its regular operators. The operators should have sessions in coordinating their equipment with firefighting equipment.

When an aircraft emergency occurs, one or more structural pumpers respond, each one manned by its regular crew. Its function usually is to pump water from sources of supply to the crash firefighting equipment. Some members of the pumper crews may assist in the firefighting or rescue operations.

Nor does the team consist only of fire protection personnel, auxiliary equipment operators, and pumper crews, there are also maintenance personnel, armament personnel, medical personnel, and security police. Each has his own particular function during emergencies, but all are a part of the coordinated team. To repeat: the grandstand player or individualist has no part in this exacting and sometimes dangerous task. Only by teamwork and complete cooperation can you reach your objective.

Exercises (C01):

1. In crash firefighting and rescue, where time is a definite factor, the degree of success depends entirely upon

   ______________________.

2. The control tower operator should supply what information about an aircraft emergency?

3. How should teamwork be developed on a precision basis?

4. What positions should a firefighting crewmember be trained to fill?

5. Why must crew assignments and training be flexible?

6. When two or more units coordinate on a firefighting operation, who is in charge of that operation?

7. What do structural pumpers and their crews do in crash firefighting operations?

8. List the members of the crash firefighting and rescue team.

1-2. Air Traffic Regulations and Runway Numbers

You may wonder why the firefighter needs to know anything about air traffic regulations. This knowledge serves two purposes: (1) It helps you detect signs of distress if an aircraft is out of the normal flight path, and (2) it indicates the ground areas where aircraft are most likely to crash during takeoff and landing. If you radio is out of order, communication with the tower is impossible. You will have to make important decisions from your visual observations of aircraft behavior.

You must understand air traffic regulations in order to know the best position for vehicles and crews along the runway. A knowledge of traffic regulations also helps you to determine the most likely crash sites during takeoff or landing. In order to understand procedures for positioning vehicles along the runway, you must first understand air traffic patterns and runway numbering.

CO2. Define given terms used in the control of air traffic and solve given problems in runway numbering.

Air Traffic Terms. To understand the meaning of a reference to the area or zone of control of air traffic, you should know the following terms:

a. Control area—an airspace of arbitrarily defined dimensions, designated by competent authority, extending upward from an altitude of 700 feet above the surface within which air traffic control is exercised.

b. Control zone—An airspace of arbitrarily defined dimensions, designated by competent authority, extending upward from the surface to the altitude of 700 feet, including one or more airports, and within which rules, additional to those governing flight in control areas, apply for the protection of air traffic.

c. Controlled airspace—Airspace designated as a control area and/or a control zone, within which air traffic control is exercised.

The control zone and control area normally include a local *traffic pattern*, which is the prescribed route for aircraft when landing or taking off. Aircraft crashes occurring within the traffice pattern or control zone can be located and reached by firefighting crew with a minimum loss of time. The traffic pattern of an air base may be shifted at any time to take advantage of wind direction. Since takeoffs and landings are made against the wind when possible, movement within the traffic pattern is always in the same direction, regardless of whether the aircraft is taking off or landing. A common traffic pattern usually has dimensions of 5 miles and 1,500 feet altitude; These pattern dimensions and altitudes, however, are governed by local conditions and the type of aircraft being flown.

The landing pattern is a path used by aircraft to line up with the active runway for

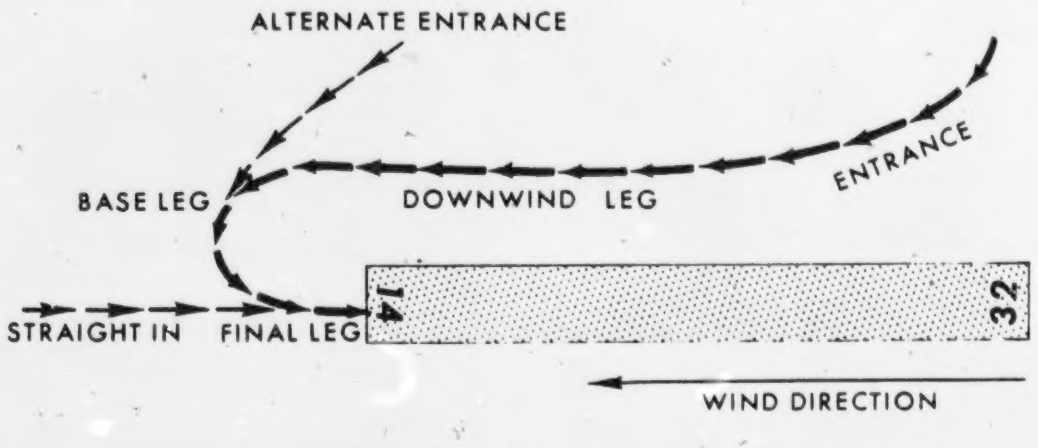


Figure 1-1. Typical landing patterns.

the purpose of landing, as shown in figure 1-1. The first side, or "leg" as it is commonly called, is parallel to the active runway and heads toward the approach end of the runway; This is known as the downwind leg. The path continues with a 90° turn to the left, which is crosswind. This is the base leg. Then, finally, a last 90° turn to the left brings the aircraft in the direction of the runway and lined up for the landing; this is the final leg. Aircraft normally enter the traffic pattern at an angle of 45° to the downwind leg. Occasionally, a traffic pattern has right-hand turns instead of left-hand turns. Because of local conditions, some traffic patterns do not have the first leg of the pattern described above, and the aircraft enters the pattern on the base leg. During some emergencies, such as flameout or power failure, the traffic pattern is not used.

The aircraft is given a clearance to make a "straight-in" approach and landing, as illustrated in figure 1-1.

Runway Numbers. With a knowledge of traffic patterns and runway numbering, you should be able to pick the best location for your truck in an emergency. During an emergency, you must be able to locate the runway and position your vehicle in the shortest possible time. One thing that makes runway numbering confusing is that each runway has two numbers. For example, if an aircraft is approaching from the south, it may be landing on runway 34. If the wind changes 180°, an aircraft would be landing from the north, and the same runway would be called runway 16. Here is the reason. Runway numbers are taken from the compass bearings, which run from 0° to 360°. By studying figure 1-2, you can see that a runway with a compass heading of 340° is numbered 34 when the aircraft is approaching from the south. When an aircraft is approaching from the north, the same runway is numbered 16 because it now has a compass heading of 160° from the opposite direction. As shown in figure 1-2, there is always a difference of 180° between the opposite ends of the same runway. Remember, runway 34 has a compass heading of 340°. When you subtract 180° from 340°, you get 160°. That is why the opposite end of runway 34 is numbered 16. The base of the number is placed toward the approach end of the runway. When the number is 6 or 9, a bar is placed under the base of the number (see fig. 1-2) to prevent confusion. Letters, where required, distinguish between parallel runways, as follows:

Two parallel runways .... 36L (Left) and 36R (right).
Three parallel runways .... 18L (left) 18C (center) and 18R (right).

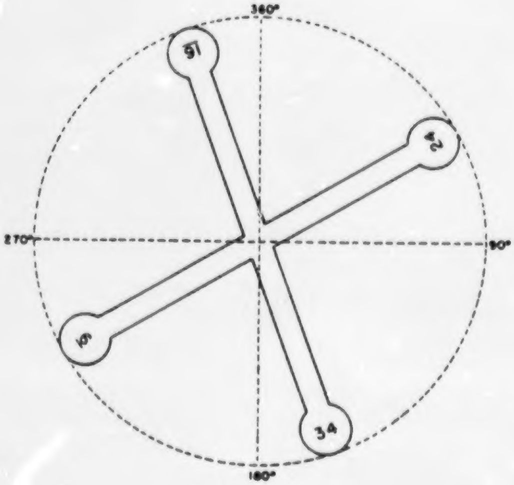


Figure 1-2. Runway numbering.

If the control operator radios "Aircraft landing on runway 34," you know that the aircraft is coming in from the south. With a knowledge of traffic patterns, you know the route he is taking to the runway. With this knowledge of traffic patterns and runway numbering, you know where the aircraft could have trouble and how to position your vehicle in the best spot and how to do it in the least amount of time.

Many factors influence the location of fire-fighting vehicles along the runway. Let us make one point clear. Vehicles do *not* remain positioned along the runway unless an emergency is known to exist. Most of the time, the firefighting crews have advance warning of a possible crash. Each Air Force base has a plan for the positioning of its fire trucks along the runway. You can see that each plan is different because the number of trucks on the base, the type of aircraft, and many other factors are different. In addition, the person in charge often makes on-the-spot changes because of wind, weather, or the nature of the emergency.

For example, assume that a crash crew is warned that an aircraft is making a landing without brakes. If the aircraft is landing from the south, most of the vehicles should go to the north end of the runway because the aircraft is almost sure to run off the far end of the runway. If the trucks are positioned at the approach end of the runway, they will have to chase the speeding aircraft all the way to the other end. On the other hand, the trucks are parked near the south end of the runway if an aircraft is going to make a wheels up (belly) landing on the south end of the runway. You know that the aircraft will not travel very far on the ground.

In short, you do everything possible to position the trucks as close as possible to the stopping point of the aircraft. When the nature of the emergency is not as clear cut as the two examples above, spread the trucks out along the runway so that at least one vehicle is very near when the aircraft stops.

Exercises (CO2):

1. What is *controlled airspace*?

2. Explain a local *traffic pattern.*

3. When possible, aircraft takeoffs and landings are made with what relationship to the wind?

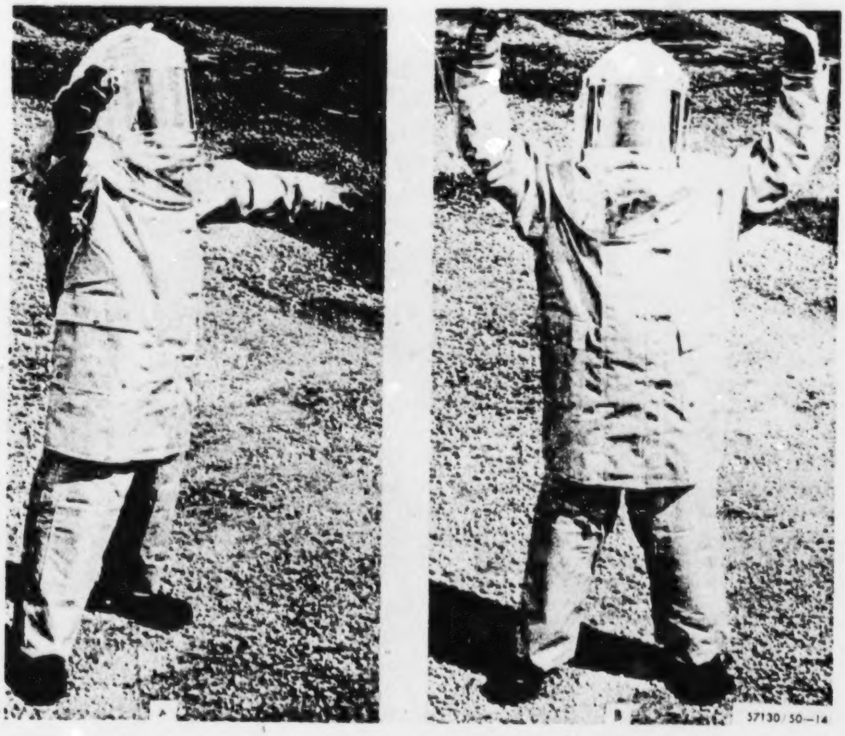
4. Local traffic patterns are governed by what factors?

5. Describe the three *legs* of a typical landing pattern.

6. What is a *straight-in* approach?

7. Where do runways get their numbers?

8. If one end of a runway is numbered 4, what is the number of the opposite end of that runway?



A. Solid stream B. Dispersed stream

Figure 1-3. Turret stream control hand signals.

9. If the control tower notifies you that an aircraft is making a straight-in approach on runway 9, in which direction should you look for the first sighting of that aircraft?

10. A bar is placed under what numbers and for what reason?

11. The opposite end of runway 12L would be ______________________.

1-3. Hand Signals

A variety of hand signals are absolutely necessary in firefighting. The excitment of an accident, the noise of the truck engines, and your isolation in the truck cab make it hard to hear. The same noises that affect you also affect people outside your vehicle. Also, they are wearing hoods and can be deafened by noises that are dampened by your cab structure. It's quite plain that voice communication is difficult and can often be misunderstood.

CO3. Given certain firefighting situations, identify the hand signals to use.

Hand Signals Between Crew Chief and Turret Operator. The crew chief is normally out in front of the truck during an emergency operation. Often during the operation, the crew chief may want to change the turret direction or pattern. As a turret operator you must be on the lookout for these signals and respond to them at once.

Turret stream control. Two of the signals used to make a turret stream change are shown in figure 1-3. The signal for "solid stream" is shown in item A in figure 1-3. The signal for "dispersed stream" is shown in item B in figure 1-3. The crew chief forms a wide circle above his head and then points to the target.

Before a turret operator can act, he must know some other facts. Suppose two crash trucks are side by side and the individual calling for turret support is standing in front of both trucks. He makes a signal calling for a solid stream. Which turret operator should act on this signal? Where should the turret operator aim the turret? The person giving the signal must make it clear to each turret operator which one is to do the task. This is why he points at the turret operator. To show the turret operator where the stream is needed, the crew chief points to the spot or area. Each time turret operator support is needed, the crew chief gives the necessary signals.

The crew chief also gives the turret operator a signal to charge the bumper turret (or ground sweep) by making a pointing motion to the bumper turret (or ground sweep), as

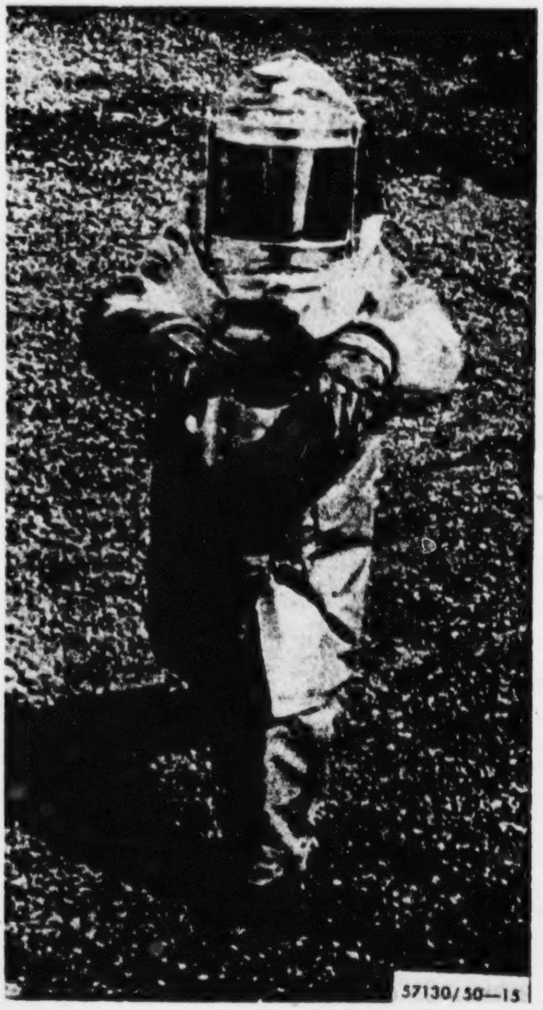

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Figure 1-4. Bumper turret (or ground sweep) signal.

shown in figure 1-4. The second time he gives this signal, he is signalling the shutoff of agent flow.

Pump control. The crew chief also has some control over the pump by giving the turret operator hand signals. If he wants the pump engine throttled up, he raises his right arm to a point where his hand is above his hood and rotates his outstretched hand in a counterwise motion. The speed of his motion may also indicate how fast the pressure should be increased.

To indicate a decrease in pump pressure, the crew chief faces the vehicle, and draws his right hand across his throat in a cutting motion. By using a combination of the last two hand signals a crew chief can attain the desired pump pressure.

When the crew chief wants the flow of agent stopped from the roof turret, he faces the vehicle, points to the turret operator, and crosses his wrist over his head.

Hand Signals Between Crew Chief and Handline Operator. The crew chief and his handline operators have the same problem in voice communication during operations at a.. accident/incident scene. With hoods in place, clear vocal orders to advance, retreat, turn, or change nozzle stream are all but impossible to hear. Here again, hand signals are used.

Ordinarily, when linemen go into a spill area, they are accompanied by a crew chief. During nozzle operation, they must use both hands to control the nozzle. Invariably, foam discharged from turrets falls on them and covers their hood facepieces, thus limiting their view. With touch signals, the crew chief can direct the "blind" lineman and never say a word to them. To be able to continue to fight a fire under these circumstances requires more than the ability of the crew chief to give signals. It requires complete confidence in the crew chief and *blind* obedience on the part of the linemen.

Upon entering the spill area, the crew chief takes hold of the lineman's coattail, or places the palm of his hand in the middle of the lineman's back. Most crew chiefs and linemen prefer the "hold" over the "place" because of the positive feel.

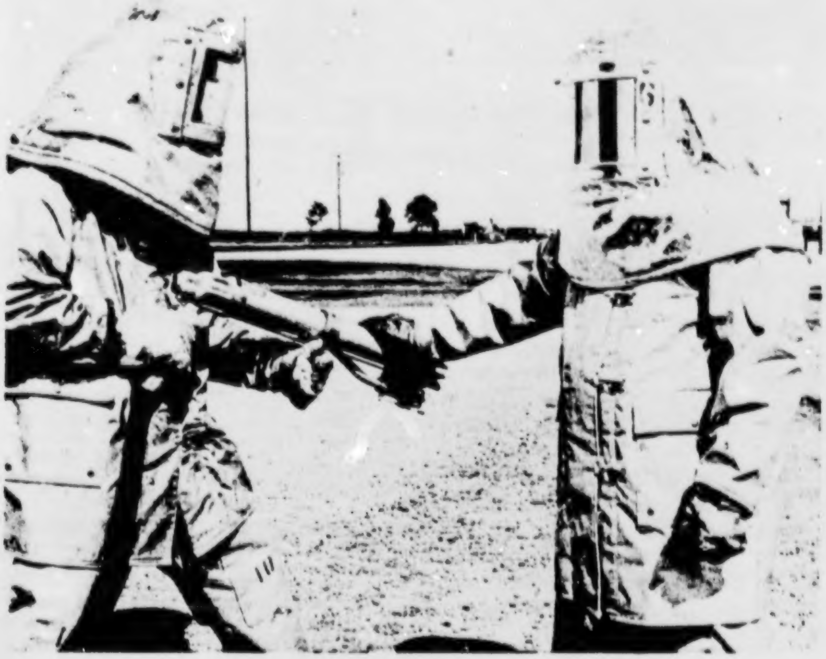


Figure 1-5. Signal for discharging or shutting off agent through foam barrel.

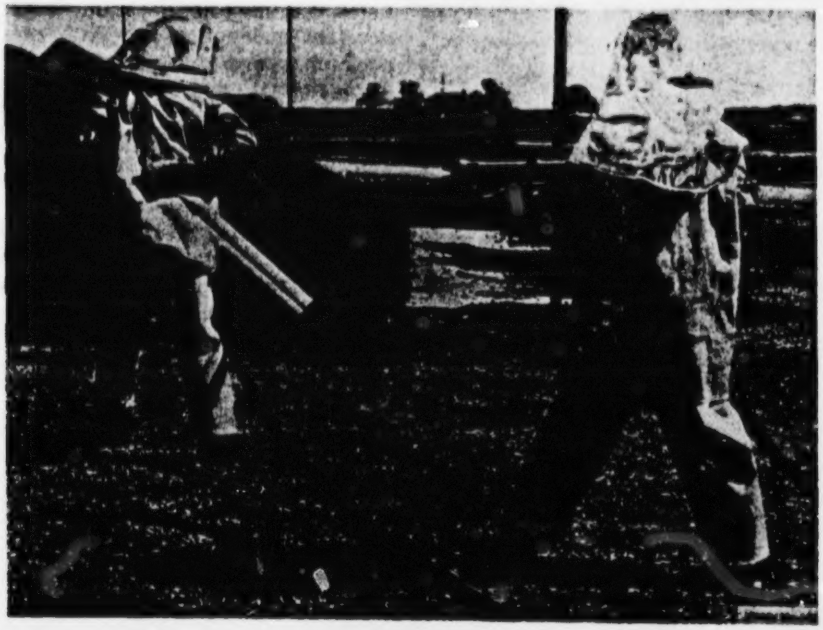


Figure 1-6. Signal to request cooling (of the back).

A steady forward push by the crew chief is the signal to advance; a steady pull signals retreat or backup. A steady tug to the left means turn left until the tugging stops; a steady tug to the right means turn right until the tugging stops. To signal a stop or "holding action," the crew chief places his hand on the lineman's shoulder.

Stream control signals. To indicate which stream he wants from the handline nozzle, the crew chief taps the appropriate nozzle barrel, i.e., top (or large) barrel for discharge from the foam barrel (as shown in fig. 1-5), or bottom (or small) barrel for discharge from the water barrel. The first time a barrel is tapped it indicates the desired barrel of discharge and when to start the discharge. When the crew chief taps that barrel a second time, it is a signal to stop the discharge.

He gives the signal for a straight stream pattern by placing the palms of his hands together, with the back of one hand down and the other up. His arms should be outstretched at midchest height for these signals. If he wants a dispersed stream, he gives the same basic signal with the exception of his hands. He keeps the heels of his hands together with the fingers of each hand separated by 4 to 5 inches; this should give you a "duck-bill" type of signal.

If the crew chief becomes separated from a lineman, he uses the same basic hand signals. The only modifications that must be made to them are; (1) the crew chief must point to the handlineman whom the signals are meant for, and (2) the crew chief uses one of his arms, held horizontal in front of himself, to indicate which agent barrel he wants and taps either the top or bottom of his arm.

A crewmember sometimes gets hot while fighting a fire. Most times it is his feet or hands that get hot first. When this happens, he may cool himself by directing the stream at the hot part of his body. If you get overheated and cannot cool yourself, you may be cooled by another handlineman or a turret operator. The first thing you must do is to get his attention. Then indicate the part of your body that you want cooled, as shown in figure 1-6. When you are cooling anyone with a handline or turret stream, you must be sure that you use a foam barrel dispersed pattern. Hitting someone with a straight stream from the water barrel will (and has) injured the individual being cooled.

Don't be afraid to ask someone to cool you as soon as you feel yourself getting hot. It's a heck of a lot better to get foamed down than to get burned. Also, remember to keep a constant watch on the other crewmembers within your field of sight regardless of the position you are working in. You can react at once in case someone gets into trouble or indicates that he is getting hot.

You may find variations of these signals in your department, but they are still used for the same purpose. You should be able to see the advantages of using the same signals throughout the Air Force.

Exercises (C03):

1. As the crew chief of a P-2 during a firefighting operation, how do you indicate to a turret operator that you want a straight stream from the roof turret?

2. As the turret operator on a P-4 positioned beside a P-2, how can you tell when a crew chief wants you to change turret streams, etc.?

3. How does a crew chief signal to a turret operator to stop the flow of agent from a roof turret?

4. If you are working a handline during a firefighting operation and your crew chief places a hand on your shoulder, what should you do?

5. How do you signal a handline operator, 10 feet away from you, to use the foam barrel of his nozzle for discharge?

6. What stream should be used to cool a fellow firefighter regardless of the appliance being used?

7. Why should you always keep watch on other personnel in your field of sight?

1-4. Runway Foaming

When the pilot of an aircraft declares an emergency, he may ask that the base fire department blanket the runway with foam. Foam applied to the runway reduces the danger of fire caused by the sparks produced when the aircraft slides on the runway surface.

C04. Describe special features of runway foaming.

Theoretical Effects. A number of aircraft emergencies, mostly wheels-up landings and defective landing gear, have occurred after foam was applied to the runways. The foam is applied to reduce the possibility of damage and fire by extinguishing any sparks caused by friction. Some operations have been successful. Others have been failures, chalked up to the fact that the aircraft missed or overran the foam blanket. Because of the lack of final facts and figures, complete guidance for runway foaming requirements is not available. However, there appear to be some theoretical benefits for aircraft landing with gear trouble:

- Reduction in the extent of damage to the aircraft.
- Reduction in deceleration forces.
- Extinguishment of sparks caused by friction.
- Reduction in fuel spill hazard due to coverage of fuel with foam.
- Favorable psychological effect on the pilot, crew, and passengers.

Request for Foaming. Every pilot who requests a foamed runway must state the nature of the emergency, estimated airborne time remaining, hazardous cargo aboard, quantity of fuel, and number of crew and passengers. All information concerning the expected foaming operation is relayed over the crash telephone circuit by the operations officer or control tower. This rapid communication with the fire department provides the maximum possible time to prepare for the task at hand.

Procedures. You should know that the water content of the foam is the part that prevents ignition by sparks from friction. As the water gradually separates from the foam mass, it stays on the surface of the runway, and effectively cools the hot fragments that are torn or *ground away* from the landing aircraft. At least 0.1 gallon of water is required per square foot of area to be covered. The use of less water per square foot cannot protect fuels from spark ignition. This fact holds true regardless of the foam depth. Only protein foam should be used and should have an 8 to

10 expansion ratio with a water drain-out period of 6 to 8 minutes. With the proper equipment and the proper application of water per square foot of area, a foam blanket can be applied satisfactorily on selected areas to an average depth of 1½ inches. Remember, the use of the correct amount of water is more important than the depth of the foam.

Protein foam is of a fairly stable nature and should stand about 4 minutes to allow enough water to accumulate for good results. After you have laid the foam, it should keep its effectiveness up to 1 hour, depending up the weather conditions. High temperatures, low humidity, and high winds have a drying action, which quickly destroys the foam. The foam pattern should be laid without breaks or bare spots on the runway. One such spot can permit ignition and destroy the effectiveness of the entire blanket of foam. The foaming crew and the stricken aircraft should be in continuous radio contact through the control tower. A change in the pilot's status or the condition of the aircraft may require an earlier landing.

The Base Operations Officer, in coordination with the fire chief and, if possible, the aircraft commander, prescribes the runway foaming, including the start-stop point and the width. The length, width, and depth of the foam pattern vary, depending upon certain factors. Some of these factors are the type of emergency, the type of aircraft, the amount of fire extinguishing agent available, and the time available. Use the following information to estimate the approximate amounts of water and foam liquid needed to lay a strip of foam on the runway. You can calculate longer or shorter strips of different widths by using appropriate multiplying factors. Study the following table to determine the relationship between the various factors.

Width (ft) of foam	*Length (ft.) of foam*	*Runway area (sq ft) covered*	*Water (gal) required*	*Foam* liquid (gal) required*
20	1,000	20,000	2,000	120
30	1,000	30,000	3,000	180
20	2,000	40,000	4,000	240
30	2,000	60,000	6,000	360
20	3,000	60,000	6,000	360
30	3,000	90,000	9,000	540

Variations of the foam proportioning system may require an increase of 1 or 2 percent of foam liquid to obtain the desired foam solution, water-holding characteristics, such as a 10-expansion, 8-minute drainage time.

Equipment. The semitrailer water distributor, after modification, is specifically authorized for foaming runways. With its large water-carrying capacity and its high-capacity pump, this truck is ideal for the purpose. The 1,000- and 1500-gallon capacity water distributors are also suitable for this use. Some bases have modified other vehicles than those already mentioned. Each base should use all the support vehicles necessary to accomplish the mission. Major pieces of firefighting equipment such as the P-2 and P-4, are not used for runway foaming.

A 2,500-gallon water distributor, with a foam tank and mixing capability, and a 500-gpm pump, can discharge 2,500 gallons of water in 5 minutes. Using the desired water coverage of 0.1 gallon per square foot, 5,000 square feet of runway can be covered per minute. In 5 minutes, 25,000 square feet of runway can be covered. This is equal to an area 8 feet wide and 3,125 feet long, 16 feet wide and 1,562 feet long, or 24 feet wide and 1,041 feet long.

A 1,500-gallon water distributor equipped like the 2,500-gallon water distributor can also cover 5,000 square feet of runway per minute. In 3 minutes, 15,000 square feet of runway can be covered. 15,000 square feet is equivalent to an area 8 feet wide and 1,875 feet long, 16 feet wide and 937 feet long, or 24 feet wide and 624 feet long.

A 1,000-gallon water distributor similarly equipped with a foam tank and mixing capability, and a 500-gpm pump, can also cover 5,000 square feet per minute. In 2 minutes, 10,000 square feet of runway can be covered. 10,000 square feet is equal to an area 8 feet wide and 1,250 feet long or 16 feet wide and 625 feet long or 24 feet wide and 416 feet long.

The exact truck speed depends upon the individual operation. You need practice and preplanning to obtain the desired results. You need constant truck speed and you can maintain it easily if you regulate the speed of the truck in accordance with the tachometer.

The foam must be removed after the stricken aircraft has landed and the runway is clear of emergency traffic. Usually, the fire department has requested the standby of special civil engineering equipment, such as hard surface sweepers or scrapers, to clean the runway after foaming operations. These vehicles start at one end of the foam strip and clean the foam off the runway.

Exercises (C04):

1. For what type of emergencies are runways usually foamed?

2. List the theoretical benefits of foaming a runway for an aircraft with gear trouble.

3. When a pilot requests that a runway be foamed, what information is he required to supply for relay to firefighting crews?

4. What part of the foam prevents ignition by sparks?

5. When a runway is foamed, how much water should be applied per square foot?

6. What type of foam is used for runway foaming?

7. Which is more important for runway foaming operations, the correct amount of water per square foot or the depth of the foam applied?

8. After foam is laid, it should stand about __________ to allow enough water to accumulate for good results, and should keep its effectiveness up to ______________

9. The runway foaming operation, including the start-stop point and width of the foam strip, is prescribed by the ______________ in coordination with the __________ and, if possible, the ____________________.

10. What factors govern the length, width, and depth of a foam pattern?

11. Which fire protection vehicles are NOT used to foam a runway?

12. When a runway is foamed, what determines the speed of the vehicle laying the foam and what should be used to insure a constant speed while foaming?

13. How is foam cleaned from a runway after a foaming operation?

CHAPTER 2

Standby and Patrol

CRASH CREWS perform many duties in addition to firefighting and rescue. Aircraft firefighting crews must constantly be on the alert for aircraft and flight-line fire hazards and spend most of their duty hours patrolling the aircraft parking ramp and the flight line. They must also provide fire protection during aircraft refueling, defueling, and maintenance operations. Firefighters may also stand by during the loading or unloading of special weapons on aircraft. Protecting the aircraft parked on its base is the fire department's responsibility. This chapter is devoted to flight-line operations that require fire protection vehicles and crews.

2-1. Flight-Line Standby Requirements

One of the duties of the base fire department is to respond to requests for standby during situations that can develop into emergencies. In order to use its equipment to the best advantage, the fire protection organization has established requirements for these standby requests.

C05. Discriminate between fire risk levels and locate fire protection vehicles during normal and emergency standby.

Nonemergency Standby Requirements. In the past, fire departments were kept very busy answering calls requesting fire trucks for standby. It became very clear that nonessential standby service requests spread firefighting trucks all over the airfield, increasing the time it took the trucks to travel to emergency situations. The added workload also increased the amount of fire truck downtime because the maintenance requirements became not only more frequent but more serious. This increase in downtime, of course, cost the Air Force more money and seriously reduced the effectiveness of vital fire-rescue services. To eliminate the waste in money and services, a request for fire truck standby is now weighted against a calculated risk. The risk is divided into three different values: mild, moderate, and severe. A knowledge of these risk values will help your fire department operate smoothly.

Mild fire risk. Most flight-line maintenance functions, such as engine runup, powered ground equipment operation, refueling and defueling, oxygen and deicing operations, and uploading and downloading weapons under normal conditions present a mild fire risk. These operations do not require a fire truck standby. The proper placement of appropriate portable or mobile fire extinguishers provides adequate protection for these operations.

Moderate fire risk. The airfield ramp fire truck can provide adequate fire protection for moderate fire risk operations. A list of these operations follows:

a. The refueling and defueling of aircraft when certain hazardous conditions exist or are expected.

b. Fuel cell purging operations within hangars or docks if the facility does not have approved ventilation and fuel vapor sensing devices.

c. Mass engine starts and movements of aircraft.

d. Welding and cutting performed in hazardous locations.

If the airfield ramp fire truck is not available, one major piece of equipment should be used for a moderate fire risk.

Severe fire/life risk. At least one major fire vehicle is required to provide standby services for the following situations:

a. Hospital evacuation aircraft transporting litter patients.

b. Class III fuel spills.

c. Nuclear weapons, missile/propellants, or high hazard items involved in accidents and/or incidents.

Emergency Standby Requirements. The term "emergency standby" describes the following condition. The aircraft informs the control tower by radio of an aircraft malfunction or aircrew member disability. In turn, the control tower notifies the fire department of the situation involving the aircraft. The fire-rescue crews then move their vehicles to pre-selected positions along the active runway. The rescue crews wait at these positions for the landing of the "emergency" aircraft. The position at which each truck waits is selected because of its area of visibility, its quick access to the active runway, the probable stopping or resting point of the landing aircraft, the surrounding terrain, and clear communication between the standby position and the radio transmitters.

Some departments are now using what is known as "selective response" for emergency standbys. In a selective response, preselected equipment responds to its assigned position depending upon the type of aircraft, nature of the emergency, local conditions, etc. By using the selective response system the department reduces wear and tear on its vehicles and reduces traffic on the flight line during an emergency. This system also eliminates the dispatching of all crash equipment for the landing of a smaller aircraft which would be adequately covered by one or two major pieces of equipment. If additional equipment is needed, it can be dispatched. During a selective response, all the crews that remain in the station, or on other standby duties, should be fully bunkered out (except for hood and gloves) and on their vehicles ready for immediate response if they are needed.

Normal Standby Requirements. One or more aircraft firefighting crews and their trucks are kept on standby status during periods of flying activity. The location of the standby point may vary with circumstances and bases. It may be within or in front of the fire station, on the parking apron or hardstand, or at some strategic location on the airfield. If necessary and practical, trucks on standby status may also be used to perform essential operational or maintenance standby duty. The fire chief determines the requirements for standby fire vehicles.

The control tower operators are responsible for closely observing all activities on the airfield and in the visible traffic pattern and for keeping in radio contact with approaching and departing aircraft. The control tower is normally the first to obtain information on an impending emergency or accident. This, however, does not relieve firefighting crews of the responsibility for keeping a constant watch, particularly during active flying periods. Some emergencies may escape the tower operator's notice.

Exercises (CO5):

1. To eliminate the waste of money and services, a request for a standby is weighed against what?
2. What are the three risk values?
3. Which fire risk does not require a standby fire truck under normal conditions?
4. How is adequate fire protection provided for a mild fire risk?
5. What is used to provide adequate fire protection for a moderate fire risk?
6. If an aircraft is being defueled in a hangar without approved ventilation and fuel vapor sensing devices, the operation is considered to be at what level of fire risk?
7. What are the minimum vehicle requirements for a severe fire/life risk?
8. What class of fuel spill is considered a severe fire/life risk?
9. Where are fire-rescue vehicles located during an emergency standby?
10. Vehicles on standby for normal flying activities are located where and who makes this determination?

2-2. Aeromedical Evacuation

Evacuating patients by air is considered a severe fire/life risk. In this section, we will describe the extensive precautions taken during this procedure.

C06. Point out selected features of the aeromedical evacuation standby procedures and specific aircraft refueling protection during evacuation.

The precautions taken with an aircraft carrying patients apply during landing, takeoff, taxiing, fueling, defueling, on-loading and off-loading. The aircraft commander, before landing, requests the control tower to notify the fire department. He also reports the number of persons and amount of fuel on board.

Usually, one fully manned firefighting truck is positioned for a normal landing or takeoff. The firefighting truck follows the aircraft to the run-up area and stands by until it is airborne. If the aircraft experiences even a minor difficulty, all firefighting trucks should respond. One firefighting truck is usually assigned to follow the aircraft from the ramp to the parking area. It then stands by while the patients are off-loaded. The recommended standby position of the firefighting truck is slightly away from the patient-loading ramp. Of course, this position may vary depending upon the type of the aircraft and local conditions. Whenever possible, the aircraft is positioned so that the cargo door or main avenue of escape faces upwind.

When an airevac aircraft, with patients aboard is fueled, the standby trucks should be repositioned, to insure that they are between the fueling operation and the main avenue of escape. Always make sure that the following requirements are observed:

- Standby firefighting trucks are ready for immediate use.
- Grounding devices are properly connected.
- Medical technicians are available at the aircraft to assist in removing patients and to give medical aid in the event of a fire.
- Except for cabin lighting, switches and electrical circuits are turned off during the fueling operation.
- After fueling, the aircraft is ventilated thoroughly before auxiliary power units and engines are started.

Normally, on- or off-loading patients is not permitted during fueling operations. However, if unusual delays will prevent meeting flight schedules, the aircraft commander may permit it.

Exercises (C06):

1. When should an aircraft used for aeromedical evacuation be provided with fire protection coverage?
2. What is usually considered as adequate fire protection for an airevac aircraft with patients on board?
3. How long is a transient airevac aircraft provided fire protection?
4. Where should the standby truck be positioned if an airevac aircraft is to be refueled with patients on board?
5. When is the refueling of an airevac aircraft not normally permitted?
6. Who gives permission for refueling under other than normal conditions?

2-3. Fuel Spills

Fuel spills are usually caused by carelessness and by malfunctions in the fuel systems of the aircraft or in the refueling system. They occur any place where fuel is used, transferred, or handled. Your job is to determine how fuel spills may be disposed of or neutralized. You have already been the hand-lineman on quite a few spills, but you followed directions from your crew chief. Remember, you may be in charge of the operation. There is a fuel spill under the wing of an aircraft. What must you do?

C07. Describe important considerations in a fuel spill operation and explain fuel spill classifications.

As with any type of operation in the fire department, some activities are very simple and safe, whereas others are extremely complex and dangerous. Fuel spills are no exception. A 10-gallon gasoline and JP-4 fuel spill in the open on a flat concrete surface does not require much disposal planning. That same spill inside a small closed area is dangerous and can present a really ticklish disposal problem.

Fuel Spill Procedures. On the flight line, where most fuel spills occur, you must determine the size of the spill and its proximity to aircraft, hangars, shops, other buildings, vehicles, fuel systems, and sewers. You must also determine whether aircraft and other vehicles should be moved from the vicinity. You must determine whether the vehicles that are parked nearby can be started or will have to be pushed away from the area. How near the fire trucks can get to the area is another problem. Should you evacuate the personnel from the flight line buildings because of potential danger? Are there ignition sources that could touch off the fumes if the concentration becomes dangerous? Can you eliminate such ignition sources as automatic heaters with pilot lights, open flames in welding shops, draft doors of furnaces, open-type switches, and arcing in electric motors? A large spill can be washed down a sewer very easily, but who is going to stand at each sewer drain to keep lighted cigarettes from being thrown into it? How do you keep the fumes from escaping from the drains and reaching a source of ignition? Have you heard of sewer lines exploding? The source of ignition may be a mile away from the point where the fuel went into the sewer. The force of sewer blasts have killed and injured people and destroyed property near the sewer drains.

How do you guard against these dangerous situations? Small spills, if they are in the open and away from danger, may be flushed with water, dispersing the fuel over a large area. The force of the water stream not only moves the fuel but also creates air currents so that the vapors cannot accumulate. You disperse small spills under aircraft in the same way except that you should direct the fuel away from the aircraft, never under it. Large spills under aircraft should be foamed down first. Then the aircraft should be moved by towing, but the towing vehicle should not be allowed in the fuel spill area until the fire officer in charge has given permission. Any aircraft that is endangered must also be moved by towing—after permission is granted. Carefully disconnect all electrical power sources as soon as possible to prevent ignition by an accidental switch movement. After the aircraft has been moved, use large amounts of water to wash the foam and fuel away to a safe area.

When fuel has been spilled, washed, or poured into sewers, they should be flushed with large amounts of water. Explosimeter readings should be taken at prescribed intervals to prevent the dangerous accumulation of explosive vapors. Dry, warm, windy weather helps considerably by dissipating the fuel by rapid evaporation and keeps the vapors below the explosive limits required for ignition. On the other hand, warm, calm, humid weather tends to keep the vapors in high concentration, increasing the chance for ignition. Even on cold days, volatile fuels, such as gasoline and JP-4, give off sufficient vapors to cause a violent reaction if the spill is not removed promptly.

Large fuel spills around refueling systems and railroad tankcar unloading areas are very dangerous because of their size and the disposal problem. Using drainage ditches to a collecting area, remote from any activity, is an ideal way to solve the problem. If your base does not have this arrangement, using foam and large quantities of water to dilute and spread the spilled fuel is a feasible method for making the area safe. If there is any doubt about the possibility of vapors accumulating at these spill areas, a guard should be p[illegible], a fire truck should remain on standby, and frequent inspections of the area should be made by a responsible person.

Fire protection equipment must not be used to remove oil and hydraulic fluid spills. The agency responsible for the spill should remove it, using an oil- and water-absorbing compound. Keep a close watch on an oil or hydraulic spill after you inform the responsible personnel that you cannot wash it down. Oftentimes, by some mysterious means, fuel gets mixed with the oil or hydraulic fluid right after you leave the area and then you are called back to wash down the fuel spill. If you encounter a situation like this, request that the assistant chief come to your location. Explain the full situation to him. He will decide whether to issue a fire hazard report or to involve the maintenance officer and/or the unit commander.

Fuel Spill Classifications. As we stated before, a class III fuel spill is considered a severe fire/life risk. What is a class III fuel spill? According to AFR 92-1, fuel spills are classified by the following criteria:

Class I. Class I (primary) spills usually involve an area less then 2 feet in any plane (flat or level) dimension. Fire guards determine whether or not these spills create a fire exposure to the aircraft or equipment. If so, agent is applied immediately. Normally, these spills need only monitoring until the aircraft is dispatched.

Class II. Class II (small) spills involve an area not over 10 feet in any plane dimension, or not over 50 square feet in area, and not of a continuing nature. These spills require the posting of a fire guard and the immediate notification of the fire protection organization. Sufficient equipment is dispatched immediately to neutralize the spill and take necessary action to eliminate the hazardous conditions.

Class III. Class III (large) spills involve an area over 10 feet in any plane dimension, over 50 square feet in area and of a continuing nature. Fire guards must be posted and the fire protection organization must be notified immediately. This condition is declared as a ramp accident/incident (severe fire/life risk). Fire suppression and rescue equipment must respond and take action to control the hazardous condition.

Exercises (C07):

1. What causes fuel spills?
2. Where do fuel spills occur?
3. Why should fuel spills not be washed into sewers?
4. Describe the weather conditions that help considerably in dissipating the fuel.
5. How should oil and hydraulic fluid spills be removed and who is responsible for their removal?
6. How large must a fuel spill be to be classified as a class I (primary) spill?
7. Describe a class II (small) spill?
8. What action must be taken on class II spills?
9. When is a fuel spill declared a ramp accident/incident?

2-4. Surveillance and Patrol

In the introduction to this chapter, we stated that aircraft firefighting crews spend most of their duty hours patrolling the aircraft parking ramp and the flight line. In this section, we will explain the purpose of this activity and the best way to do it.

C08. State the purpose of ramp and flight-line surveillance and give some approved patrol procedures.

Surveillance. The purpose of ramp and flight-line surveillance is to detect unsafe conditions in these areas. Surveillance is performed by fire protection personnel patrolling their assigned areas, from an established surveillance post, using the P-13/P-13A (or a major piece of firefighting equipment when so directed), or by alarm center personnel if the location of the alarm center permits maximum visual surveillance of the flight-line operational area.

If you are performing surveillance, your objective is to locate, identify, and correct any unsafe condition or hazard before it develops into an accident or incident. If you note any unsafe condition, notify the responsible authorities at once to eliminate or correct it.

NOTE: Before you take a stationary surveillance position, check with the alarm center by radio to make sure that your vehicle is not in a *dead-spot* and that you have adequate communication.

Patrol. In most cases, crews are assigned to patrol the flight-line and maintenance areas for specific time periods. Coverage of these areas is usually provided on a 24-hour basis. The exact manner in which patrolling is done varies from base to base and is determined by the fire chief. As a rule the crew on patrol keeps its vehicle moving throughout its assigned area until the crew is dispatched to a specific standby operation.

The patrol vehicle should have a crew of two, one of whom is bunkered out. For safety reasons, the vehicle driver does not normally bunker out during the roving patrol time. The nozzleman should be bunkered out, except for his hood and gloves, to insure the fastest possible reaction to an emergency. If the outside air temperature is very high, and the high temperature coupled with the bunker clothing could affect the nozzleman's effectiveness, he may be permitted to preposition his bunker coat on the back of the seat and push his bunker trousers down below his knees.

Again, the fire chief decides on the practices to follow.

In a roving patrol, it is best NOT to establish a set patrol pattern or time schedule for a specific area. If you can be counted on to pass a certain point every so many minutes, personnel working at that location can make it appear when you pass by that their activities are satisfactory, when in fact they are breaking the rules. This may sound crazy but it does happen.

It is a good idea to stop every so often and watch some operations. The sight of that red truck sitting out there may be just enough to make someone follow the step-by-step procedures for the task he is doing instead of taking a dangerous short-cut.

Exercises (CO8):

1. What is the purpose of ramp and flight-line surveillance?

2. What is your objective while performing surveillance?

3. When you note an unsafe condition, whom should you notify?

4. Who determines the manner in which patrolling is to be done?

5. Why is it best NOT to use a set pattern or time schedule for your roving patrols?

6. What effect may your stopping and watching a maintenance operation have on the personnel performing that operation?

CHAPTER 3

Command and Control

EACH BASE MUST maintain an adequate fire protection organization, which is responsible for all firefirefighting and essential aircraft and missile fire-rescue service. Where aircraft fire-rescue services are required, all services are integrated into a single fire organization with maximum cross-usage of personnel and equipment. Aircraft fire-rescue services must extend to all reasonably accessible areas in the vicinity. Most of what you are about to learn of aircraft firefighting is preplanned, the result of looking ahead to what might happen and then doing everything possible to prevent it or to be "Johnny-on-the-spot."

Basically, the firefighting processes that deal with burning aircraft can be divided into seven operations to be covered in this chapter. Those aircraft that develop difficulties but do not actually catch fire are not affected by all seven of these operations: (1) the approach of the firefighting trucks, (2) their positioning with regard to the aircraft, (3) the methods used to attack (combat) the fire, (4) the suppression of the fire to a point of control, (5) the rescue of trapped or injured aircrewmembers or other personnel, (6) the extinguishment of all visible fire, and (7) the final extinguishment accomplished by overhaul.

3-1. The Approach

There is almost no limit to the number of things to consider during the approach. Your job is to get to the emergency in the fastest and safest way, and to do this, you must consider the type of roads and the terrain between you and the emergency. You must be ready to drive in all kinds of bad weather and must also know the capacity of the bridges and roads in the area. These are but a few of the many items to be considered during the approach.

C09. Give some of the important considerations in the approach to a crash/fire.

The ideal approach to a burning aircraft is upwind, but an ideal approach may not be the best for a successful rescue. The distance and time required for an upwind approach may be good reasons for rejecting it. If time is not vital to the immediate start of a rescue, then use the extra time to make an upwind approach.

Although an airbase is supposed to be cleared of all air traffic when an aircraft accident occurs, other emergencies may prevent this action. Another emergency creates a hazard for the trucks and their crews when they are using the runways as the most direct route to the accident. To guard against the danger of a collision between the responding trucks and a moving aircraft, the crew chief of each truck should assign crewmembers as *watchers* to warn the driver of impending danger and of any control tower light signal. Vigilance on the part of these watchers cannot be over-emphasized, for the safety of all members of the crew is at stake.

If the firefighting crews have been given prior notice of an emergency landing and are positioned along the runway, there is always the danger of the aircraft taking an unexpected path, particularly when it is landing with faulty landing gear. Its malfunction may divert the aircraft from its original direction on landing. Always consider this possibility when you are positioning equipment.

Speed and coordination are essential when a crew is responding to an emergency. Just a few seconds can determine the success or failure of its rescue efforts. Trucks should travel as fast as air base directives and conditions permit without sacrificing safety for speed. Battles may be won "by them that gets there fustest with the mostest," but they can't be won by those who don't arrive at all.

Speed is necessary, but recklessness is dangerous. The overall weight of the truck is a factor that the driver must consider when he is responding to an emergency. Water weighs 8.35 pounds per gallon. In addition to the equipment and personnel on a P-2 crash truck, for example, the weight of the water is well over 9 tons. A curve taken too sharply will force the water to the outside of the curve, changing the center of gravity. This could tip the truck over, injuring or killing its passengers. Although baffle plates installed in water tanks retard the motion of the water, they are by no means a cure-all. The trucks are designed as carefully as possible, but placing too great a stress on their parts could result in serious accidents, so we repeat: *The truck must arrive at the scene of the emergency in firefighting condition if the operation is to be successful.*

When a crash occurs on base, the scene of the crash becomes a collection point for a great variety of vehicles, most of which are not authorized to be there. This condition not only creates an additional hazard to the emergency vehicles but, in many cases, prevents them from making a proper approach. The security police, as part of the team, must correct this condition as quickly as possible. Time is a factor, but the drivers must combine their driving with good judgment.

En route to the scene of an aircraft emergency, all members of the crew should watch for parachutes from the stricken aircraft. During the immediate approach, examine the terrain closely for aircrewmembers who have been thrown clear or jumped from the aircraft before or when it stopped. This practice can help in determining the number of aircrew remaining in the aircraft.

On the approach to the scene of an incident, you should maneuver your vehicle to the most advantageous, yet safe, position so that the turret operation will be the most effective. If your truck is the first to arrive at the scene, depending upon your fire chief's plan for setting up, you usually set up on the nose or tail of the aircraft with the other trucks positioning on you. The basis for your setup position is your department's operating instructions which cover the general conditions you can expect to encounter. There may be times, however, when you will have to decide where the approach should be made so that the control of the fire can begin.

The approach to any aircraft incident is, in reality, started long before it actually happens. The whole operation was partially preplanned before you became a fire protection specialist. All of your training has been directed toward the time when you take your part in preplanned operations. The approach is only a part of the whole operation.

Exercises (C09):

1. How is the ideal approach to a crash/fire scene made?

2. Give two good reasons for not making the ideal approach?

3. What action should a crew chief take to guard against a collision between responding vehicles during an emergency response?

4. What hazards are present when vehicles are in position along a runway during the emergency landing of an aircraft with landing gear problems?

5. How fast should the vehicles travel while responding to an emergency?

6. During the immediate approach to a crash/fire scene, why should you watch the terrain closely?

7. Give the basis for your setup position at the scene of an incident.

C10. Explain the factors that govern the approach to a crash/fire scene.

Wind. Normally, the wind direction is one of the deciding factors on how to make the approach. As we stated, upwind is the ideal approach position. The turret and handline streams reach the farthest and there is less danger to your crew and truck. This does not always reduce the danger to the people trapped in the aircraft. The upwind side may not always be the safe side because of terrain feaures or armament loads. To get to the upwind side sometimes requires more time than you can afford. The area of the burning fuel may determine the direction of the approach. The number of personnel in the aircraft may also require a different approach. Whenever possible, use the wind to your advantage in firefighting and rescue operations. Only when there is no other safe way to reach the scene should you fight a fire against the wind.

Terrain. As we mentioned before, the terrain has a great deal to do with how your approach should be made. The normally smooth, level ground around the runway/flight line area doesn't present much of a problem except when it is wet or covered with snow. But what about an area a quarter-mile or so from the runway? It is probably not at all like the runway area.

Hills, woods, lakes, ponds, streams, ravines, cliffs, mountains, and structures are all part of the terrain features to consider when you are determining your approach. Some of these features can form a barrier to your otherwise normal approach. The position of the aircraft on the terrain may also be the primary factor when all other factors have been duly weighed.

Type of Aircraft. The last factor we will discuss in determining an approach is the type of aircraft involved. As you know by now, there are a great many types of aircraft in use today. They range in size from the small T-41 trainer to the giant C-5 transport. If you don't know what type of aircraft is involved in a crash, plan your approach for the left side of the aircraft. When you know the type of aircraft, plan your approach to the rescue side. When possible, plan the approach far enough in advance so that you don't have to do a lot of maneuvering at the last minute to get into position.

Take a lesson from the pilots you protect. A long straight-in approach is generally better than a short approach with a lot of maneuvering. Not only do you have a better view of the scene on a *straight-in* but the other crewmembers do too.

Each of the three factors, wind, terrain, and type of aircraft, has to be taken into account during the approach. No one factor always overrides the others. It will be up to you as crew chief of the *first-in* truck to determine the relative importance of each factor and to act accordingly. Your decision can mean the difference between life and death for aircraft members and firefighters.

Exercises (C10):

1. Why is upwind the ideal position to take for an approach?
2. When should you fight a fire downwind?
3. When should you expect the terrain adjacent to the runways to present problems in approaching an aircraft incident?
4. When does the position of the aircraft affect the approach?
5. How should you approach a crash site when you don't know what type of aircraft is involved?
6. How should you plan the approach when you know the type of aircraft?
7. What lesson in approaching can you learn from a pilot?
8. Who normally determines the relative importance of each approach factor and acts accordingly?

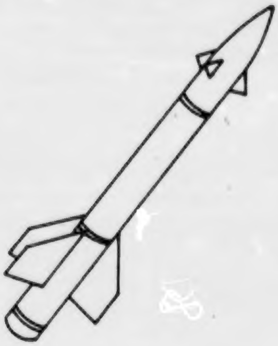
3-2. Position

The position step in firefighting can be divided into two separate parts. The first part is to position aircraft firefighting vehicles and crews along the runway when you know that an aircraft will be making an emergency landing. The second part of the position step is to put the vehicles in the best position at the scene of the crash or emergency. This is called "setting up on the aircraft." Since we have already discussed positioning along the runway, we will turn to on-scene positioning.

C11. State some of the basic rules for setting up firefighting vehicles at the scene of an aircraft fire/crash, and given the needed details, describe an ideal setup.

It would be all but impossible to describe every possible setup. There are too many factors to consider when an accident occurs. Some of these factors are weather, wind direction, terrain, type of aircraft involved, location of accident, and number of trucks available. We will give you a few basic principles to help you determine the most acceptable plan of action.

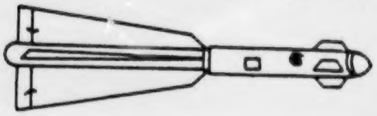
Positioning. An old rule for crash firefighting is "First truck in splits the fuselage." (The first truck arriving at the accident positions on the nose, or the tail, for controlling the fire on both sides of the fuselage.) The rule is still useful in most cases, though there are no hard and fast rules governing the position of trucks. There are times when the normal procedure (the first truck positioned on the nose or tail of



CONVENTIONAL WARHEAD
CARRIED ON FIGHTER AIRCRAFT

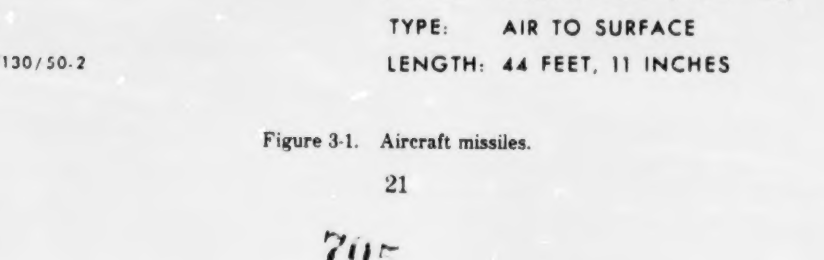
NAME: BULLPUP (AGM—12A)
TYPE: AIR TO SURFACE
LENGTH: 11 FEET

CONVENTIONAL WEAPON
CARRIED ON FIGHTER AIRCRAFT



NAME: FALCON (AIM—26A)
TYPE: AIR TO AIR
LENGTH: 7 FEET

NUCLEAR WARHEAD
CARRIED ON B52 BOMBER AIRCRAFT



NAME: HOUND DOG (AGM—28)
TYPE: AIR TO SURFACE
LENGTH: 44 FEET, 11 INCHES

57130/50-2

Figure 3-1. Aircraft missiles.

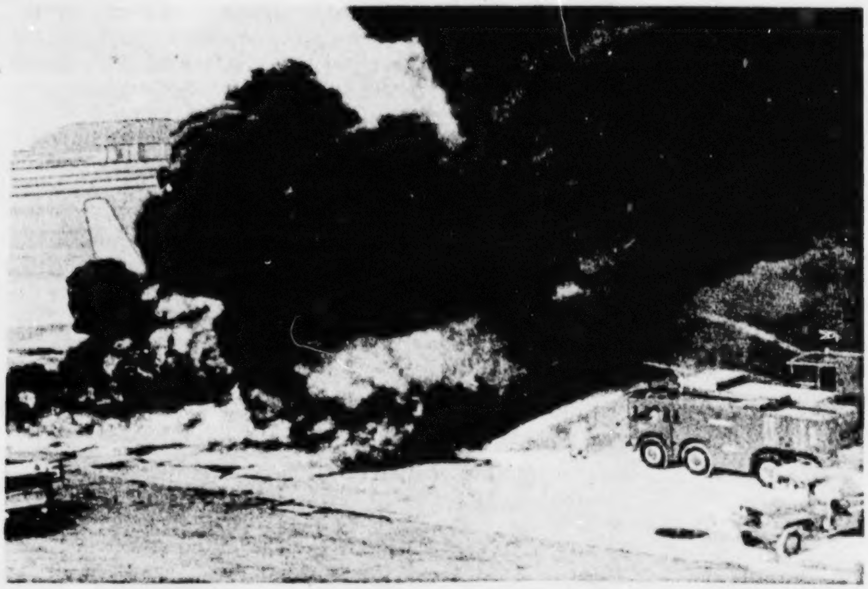


Figure 3-2. Mass application attack.

the aircraft) should not be followed. For example, suppose the P-2 is following right behind your P-4. The P-2, with its volume discharge and long range, could be more effective at the center position than your P-4. You must use your judgment in situations like this because the sooner the agents are applied to the whole fuselage, the better the chance for survival of the personnel within the aircraft. Five or ten seconds can truly be a lifetime if you wait for another truck to fill the gap you leave open. Good judgment on the part of the crew chief and driver puts the truck in the most effective position.

This judgment requires a rapid evaluation of known facts. The trucks must be placed within range for the use of their turrets and handlines. These turrets play the most important part in controlling the fire around the fuselage and providing protection for rescue team members. The driver must also position the truck so that it can advance or retreat as circumstances dictates.

Sequence. The normal sequence of positioning trucks on aircraft is as follows: the first truck arriving positions on the nose or tail; the second truck positions on the rescue side of the fuselage; the third truck sets up on the opposite side of the fuselage; and this continues until all trucks are in position. As we said, this is the normal sequence of positioning. You will respond to accidents that require a different sequence to fit unusual circumstances. The terrain (hilly, smooth, tree-covered, etc.), the condition of the ground (dry, swampy, snow, sand, etc.), the type of aircraft (armed or unarmed fighter, cargo, passenger, tanker, etc.), and the condition of emergency (intact, broken apart, on fire, etc.) are all involved in the positioning of the trucks.

Hazards. One of the most important factors to consider when an accident occurs is the armament. There may be guns in the nose, wings, or tail. There may be rockets and/or missiles (such as those shown in fig. 3-1) under the fuselage or wings. There may be bombs in the fuselage. Other factors of importance are the danger areas in front of and behind jet engines and gas turbine generators if they are running. (Consult TO 00-105E-9 for danger areas on specific types of aircraft.)

The firefighting truck must approach and take its position carefully to avoid moving in front of, or positioning in front of, fixed guns, cannon, or rockets. The same consideration must be given to moving and positioning in areas behind jet engines and gas turbine generators. The terrific wind and heat expelled by these units can injure the firefighters and damage the equipment.

Most types of aircraft create danger zones in the area of their main landing gear wheels. If there is excessive braking during the landing roll, tire blowouts, wheel fires, and the ignition of flammable liquids in the area may be the result. As we stated before, positioning trucks on aircraft depends upon existing conditions. If, for instance, an unarmed fighter or trainer crashes and the engines are not running, you can use the ideal setup, that is, one truck (P-2) on the nose with a P-4 on each side of it. If the aircraft is armed with forward firing guns or cannon, the P-2 and one P-4 should be on the rescue side and the second P-4 should be on the off-rescue side. All vehicles should remain clear of the normal field of fire for the weapons. If the aircraft is carrying missiles, the safest approach and positioning is to the front of the missile at an angle of 45° from the longitudinal axis.

If an emergency involves an aircraft that is carrying missiles, it is almost impossible to approach the aircraft or position the vehicles without entering a danger area. These areas are in front, at the back, and at the wingtips. Some calculated risk must be taken. Rescuing aircrewmembers during an emergency makes the risk worth taking.

Distance. As you probably know, the attack on the fire has already started before the trucks are completely positioned. The turrets should be readied for instant operation before the attack, and when the truck is within range of the fuselage, you can start the discharging agent to cool and protect the fuselage. How far away from the aircraft should you stop the truck? The answer can only be *the safe distance*. What is the safe distance? Only the circumstances of the incident and your judgment can answer that. Two feet away from the fuselage may be perfectly safe but a deep fuel spill may make a distance of 20 feet away dangerous. The use of your bumper turret may extinguish the fire, but what may happen when the wheels of your truck disturb the foam blanket covering the spill? What may happen when the handlineman dismounts and, pulling the line to go into operation, disturbs the foam blanket?

Location. The larger the aircraft, the more trucks you should use, but the same basic principles apply. Your first three trucks in would set up in the same way as on the smaller aircraft with the following exceptions. If the two trucks in are P-2s, one should be placed on each side of the nose. The third truck in should be positioned on the primary rescue side, the fourth on the off-rescue side, the fifth on the rescue side, and so on.

The senior fire officer, of course, can change these positions if the need arises. There is no need for positioning one or two vehicles on a side of an aircraft where there is no fire. Another key factor is the location of the aircrewmembers/passengers. If there are people in the rear of the aircraft, don't forget to position your vehicles to cover them. Don't keep all your vehicles in one area just to make it look good in a drawing or picture. Provide maximum coverage for the victims and to heck with looks.

Terrain. If the incident occurred on a slope, which way should you position the truck? Uphill from the aircraft is the most logical position because the flow of fuel would be down the hill. But there are other factors to consider before the final decision is made. You must consider the wind velocity and direction, the terrain, the time it takes to position on the uphill side, the steepness of the slope, the area of the fire, the number of personnel in the aircraft, the access to the uphill side, the type of aircraft, the number of crash vehicles responding, and the number of personnel on the vehicles. All these factors affect the approach and positioning of your vehicles. With the first vehicle in position, the rest of the vehicles are generally committed to attack from that point.

Most of the foregoing material has dealt with the nose or tail approach. At times, conditions and circumstances require a broadside setup to the fuselage. This again requires jugement on your part as a skilled firefighter or supervisor. The requirements to be met on any approach to an aircraft accident are: (1) accessibility to the aircraft for effective use of the turrets and handlines, (2) the speed with which the fire around the fuselage can be controlled, (3) the speed with which the rescue effort can begin, and (4) the reasonable safety of the firefighters.

Exercises (C11):

1. List the factors to consider when you are positioning a firefighting vehicle at an incident scene.

2. State the crash firefighting rule that describes the usual positioning of vehicles.

3. List the hard and fast rules for the positioning of vehicles.

4. What equipment plays the most important part in controlling the fire around the fuselage of an aircraft?

7-2

5. Describe the normal sequence of positioning trucks on an aircraft.

6. What important aircraft characteristic must you take into account when you are positioning a truck near it?

7. How can you learn the danger areas for specific types of aircraft?

8. What is the safest position to take near an aircraft carrying missiles?

9. How far from a crashed aircraft is your vehicle when it is in the proper position?

10. How do you determine the safe distance from a crashed aircraft?

11. Describe an ideal setup on a large bomber, using three P-2s and two P-4s (all aircraft crewmembers are located forward).

3-3. Control and Extinguishment

When we discussed structural firefighting, we stated that the attack phase starts when the first firefighting agent is put on the fire. We also stated that the approach, position, and attack phases of firefighting often overlap. The same statement is true of aircraft firefighting. The phases overlap to some extent. The attack starts when you put the first agent on the fire and ends when the fire (or part of the fire) is under control. During the attack step, you also consider the wind, terrain, type of aircraft,and the many other things that we discussed during the earlier steps. Your most important objective during the attack is rescuing the people in the aircraft. First, you must know their location. Next, you must know the fastest and safest way to get to them and remove them. To do this, you must know the location of the aircraft's entry points. In fact, to make a good fire attack, you must apply almost everything we have discussed in this entire course. You must apply what you learned about the P-2 and the P-4. You must know how to rescue and how to use the rescue vehicle tools and equipment. During the attack step, you must be able to use hand signals and to operate turrets and handlines. During the attack step, the turrets direct their agent onto the fire using the fuselage as the main target area. The handline operators get out of the vehicles and remove their handlines and working line. The crew chiefs are out of the trucks and directing their crews.

C12. Point out selected features of the attack, control, and extinguishment phases in an aircraft crash fire, and given a list of colors, identify them in the tubing color code.

Attack. Like the positioning of vehicles, the attack is governed by existing conditions. The principal points of concern are the probable location of personnel trapped within the aircraft and the location of its access doors or points of forcible entry. These entry points may be affected by fire, gun positions, presence of bombs, hazardous cargo, and pyrotechnics.

The most widely used concept of attack for quick control (not extinguishment) is a volume (mass) application of agent from the turrets, with a minimum use of handlines (as shown in fig. 3-2). The initial attack starts during the approach, using the turrets when the firefighting truck is within range.

The pump engines on the trucks should be at maximum throttle with the pumps supplying the turrets at full capacity. The turrets should be set for straight stream, foam, and full capacity. You open the roof turrets when the truck is within range of the accident. You open the bumper turret when it is within reach of the ground fire. The important point to remember is this: regardless of how large the fire is or where it is, the fuselage area is the agent target. Cool the fuselage where the crew or passengers are and continue to keep it cool until they are rescued. It is not good firefighting to waste your agent on a wing fire and run out of agent before rescue has been completed. A good turret operator knows when to index a turret from straight stream to dispersed pattern for the best application and conservation of agent.

As soon as the truck has come to a stop, the fully protected linemen dismount, remove their nozzles and hand lines from the compartment,

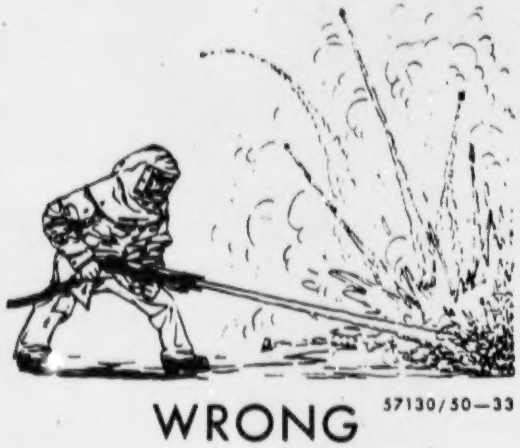


Figure 3-3. Applying foam improperly.

and take their positions as directed by the chief and fire department policy.

Control.

The area to control is around that part of the fuselage where aircrew or passengers are suspected or known to be. Controlling the fire in this area keeps the fuselage cool, and with the fuselage cool, the victims are protected from the heat.

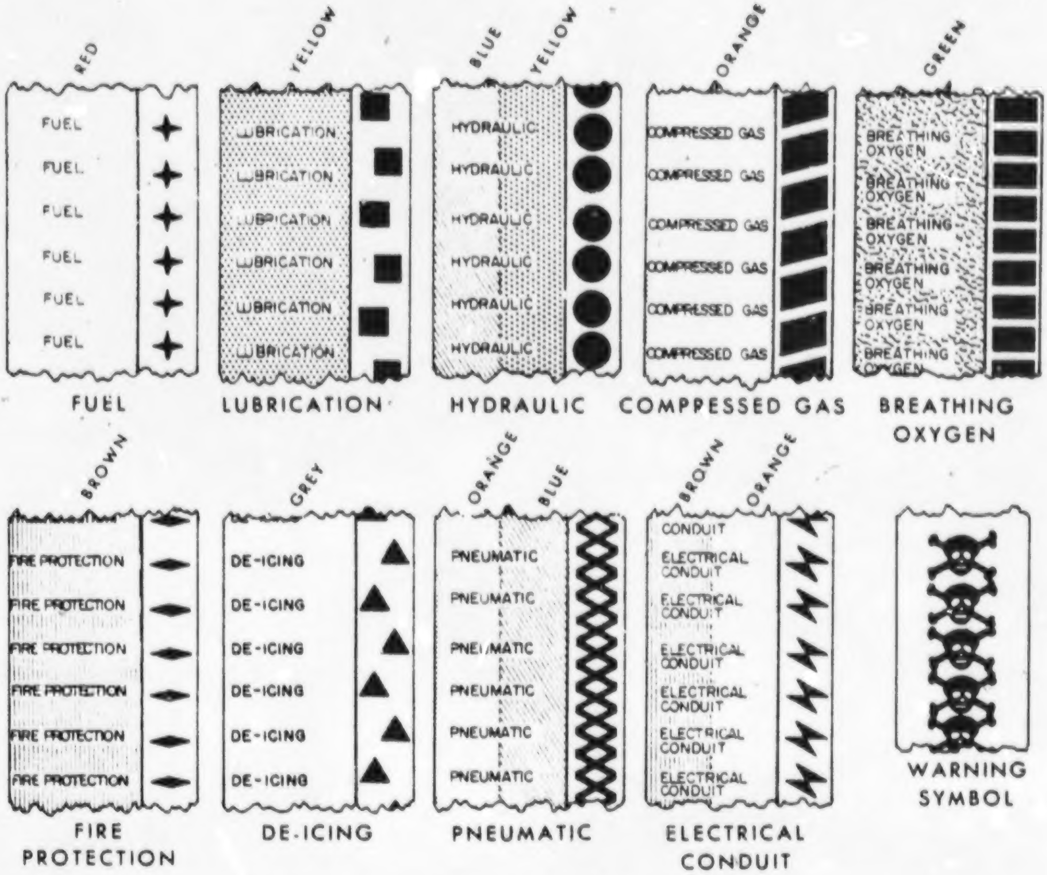
You start control on the *approach* by using turrets and must maintain it during the rescue effort. Handline operators may be used in this phase to control any fire under or around the fuselage that the turrets cannot reach. (Whenever the handline operators are in front of the truck and in range of the turrets, the turret operator should be particularly careful not to strike a handline operator with a straight stream. This stream has sufficient power to knock him off balance if he is hit squarely or to seriously injure him if he is hit in the head or lower back.)

In controlling a fire around an aircraft with foam, one of the dangers a handline operator can encounter is a backflash. The word "backdraft," another new word in your vocabulary, is caused by lack of oxygen in a closed burning area. The cause of a backflash is somewhat similar to the cause of a backdraft. When burning fuel is extinguished by foam, it is actually smothered by the foam blanket floating on top of it. It cannot release its flammable vapors up through this blanket in sufficient quantities to cause fire unless the foam is of poor quality or the foam blanket has been disturbed. This foam blanket actually excludes, or cuts off, the supply of oxygen to the fuel. When the foam blanket is disturbed, it leaves raw fuel exposed, and when the fumes travel to the area involved in fire, the result is a backflash. When AFFF is used for firefighting, the danger of backflash is greatly reduced but still exists. If the AFFF is not applied properly or if the percentage of foam concentrate is too low, the chances of a backflash increase.

During positioning, attack, control, rescue, extinguishment, and overhaul, the danger of backflash is present. The application of foam usually starts during the positioning phase. By the time the last truck is positioned, there is normally a considerable amount of foam blanketing the fuel around the fuselage. If a turret is not set correctly, the straight stream will *plow* an opening in the foam blanket, exposing the fuel and causing its reignition. As we said before, AFFF lessens the chance of backflash but does not completely eliminate it. For this reason, protein foam and AFFF should NOT be used on the same fire except as a last resort. You must also remember the proper way to apply both types of foam (rainfall or lobbing effect for AFFF and "build-up and roll-in" for protein foam). Streams from a handline can also expose the fuel by *plowing up the area*, as shown in figure 3-3.

During the attack, control, rescue, extinguishment, and overhaul phases, firefighters are walking through the foam, some dragging handlines or other equipment, and disturbing the foam blanket to different degrees. These disturbances expose the fuel to the air, and reignition or backflash can occur at any time. These backflashes can be the size of a footprint or they can be as large as the area saturated with fuel. These backflashes can surround or engulf a person in the area at nearly explosive speed. Everyone should be particularly careful while operating the turrets and nozzles within the danger area.

The control of the fire at an accident does not necessarily mean the complete extinguishment of the fire. Fires involving small areas are usually extinguished during the initial control of the fire. Larger areas of fuel may not be extinguished at all but be allowed to burn out by themselves. The area next to the fuselage where personnel or dangerous or valuable cargo is located must be controlled and the control of the fire in this area must be maintained until rescue and removal have been


RED
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
YELLOW
LUBRICATION
LUBRICATION
BLUE
YELLOW
HYDRAULIC
HYDRAULIC
ORANGE
COMPRESSED GAS
COMPPESSED GAS
GREEN
BREATHING OXYGEN
BREATHING
OXYGEN
BROWN
FIRE PROTECTION
FIRE
PROTECTION
GREY
DE-ICING
DE-ICING
ORANGE
BLUE
PNEUMATIC
PNEUMATIC
BROWN
ORANGE
CONDUIT
ELECTRICAL CONDUIT
ELECTRICAL
CONDUIT
WARNING
SYMBOL

THE ABOVE COLOR CODES REPRESENT DESIGNATION FOR SYSTEMS ONLY FOR CODING LINES WHICH DO NOT FALL INTO ONE OF THESE SYSTEMS THE CONTENTS SHALL BE DESIGNATED BY BLACK LETTERING ON A WHITE TAPE.

SUBSIDIARY FUNCTIONS OR IDENTIFICATION OF LINE CONTENT MAY BE INDICATED BY THE USE OF ADDITIONAL WORDS OR ABBREVIATIONS WHICH SHALL BE CARRIED ON A SECOND TAPE ADJACENT TO THE FIRST OR ALTERNATIVELY, INTERPOSED BETWEEN THE WORDS DESCRIPTIVE OF THE MAIN FUNCTION.

WARNING SYMBOL TAPES, 3/8-INCH WIDE, SHALL BE APPLIED TO THOSE LINES WHOSE CONTENTS ARE CONSIDERED TO BE DANGEROUS TO MAINTENANCE PERSONNEL. WARNING TAPES ARE TO BE PLACED ADJACENT TO SYSTEM IDENTIFICATION TAPES.

ONE BAND SHALL BE LOCATED ON EACH TUBE SEGMENT, 24 INCHES OR SHORTER ONE BAND SHALL BE LOCATED AT EACH END OF EACH TUBE SEGMENT LONGER THAN 24 INCHES ADDITIONAL BANDS SHALL BE APPLIED WHEN THE TUBE SEGMENT PASSES THROUGH MORE THAN ONE COMPARTMENT OR BULKHEAD AT LEAST ONE BAND SHALL BE VISIBLE IN EACH COMPARTMENT OR ON EACH SIDE OF THE BULKHEAD.

PRESSURE TRANSMITTER LINES SHALL BE IDENTIFIED BY THE SAME COLORS AS THE LINES FROM WHICH THE PRESSURE IS BEING TRANSMITTED.

FILLER LINES, VENT LINES DRAIN LINES OF A SYSTEM SHALL BE IDENTIFIFD BY THE SAME COLORS AS THE RELATED SYSTEM.

TAPES SHALL NOT BE USED ON FLUID LINES IN THE ENGINE COMPARTMENT WHERE THERE IS A POSSIBILITY OF THE TAPE BEING DRAWN INTO THE ENGINE INTAKE. FOR SUCH LOCATIONS, SUITABLE PAINTS, CONFORMING TO THIS COLOR CODE, AND WHICH HAVE NO DELETERIOUS EFFECT ON THE MATERIAL USED FOR THE LINES, SHALL BE USED FOR IDENTIFICATION PURPOSES. IN THESE CASES THE GEOMETRICAL SYMBOLS MAY BE OMITTED.

Figure 3-4. Coding system.

completed. Fire in an area that is not endangering the operation is held to that area without any attempt to extinguish it.

This action conserves the extinguishing agent that must be used to keep the heat of the fire away from the fuselage and the people in that area. The foam available on the vehicles at the accident may be the only foam you have. Use these agents as they are needed, but do not waste them. When the control of the fire has been established, short bursts of agent should be sufficient to hold the control until the rescue operation is completed. Then the complete extinguishment of the fire may proceed.

Extinguishment. Ordinarily, you do not try to extinguish the fire completely until the rescue operation has been completed. The reasons for this are that (1) it generally requires all manpower available to protect the rescue team members and the victims until the rescue operation has been completed, and (2) because the length of time needed for rescue cannot be determined, the conservation of extinguishing agents is vitally necessary. However, there are times when the type of aircraft and the amount of equipment and manpower available justify complete extinguishment and rescue at the same time. If an aircraft has crashed with considerable impact, fuel lines are probably broken. You must plug or crimp these before extinguishment is possible. For this reason, you should know how to tell which lines contain flammable fluids and which do not.

Color code system. In a multitude of hoses, conduits, and tubing of approximately the same size and appearance, it is difficult to distinguish one from another. This is especially true when you must trace one specific line from one position through walls or bulkheads to another position. It is of the utmost importance that you, as a firefighter, can determine what is contained in all the tubing in an aircraft. In your firefighting duties, you may have to cut or crimp certain lines. You must certainly know what is in a line before you do anything with it!

To simplify the installation, repair, and maintenance of tubing systems, a standard marking system has been devised to aid in the rapid identification of their contents. Actually there are three ways to identify the contents of the tubing, as shown in figure 3-4: by (1) colors, (2) words, and (3) geometric designs (symbols). There is a reason for each of the three methods. Color can be recognized from a greater distance and is therefore faster. The words are necessary for the color blind. In addition, color is sometimes lost because of fire, smoke, and heat. Foreign mechanics can recognize and remember the geometric symbols more easily than the words. All Air Force firefighting specialists are required to memorize the color code.

In the directions for colorcoding tubing, you will find some interesting information. They tell you what is to be color-coded and, if the tubing does not require coding, how it is to be marked. They tell you the way additional information is added to the tubing as well as the dangers involved in certain systems, and give you the spacing and specific locations for the marking tapes. They also state that all parts of the system, whether filler, vent or drain lines, or lines from the supply lines to the unit using the material in the lines, must be marked the same. They give clear-cut directions for areas that are not to be taped and for identifying the lines in those areas.

Burning magnesium. When the fire of a crashed aircraft involves magnesium parts, such as wheels, great care must be taken to prevent injury to firefighting personnel. Because magnesium combines readily with oxygen, extinguishing this material presents a problem. Most extinguishing agents have little or no effect on burning magnesium. One of the effective principles of extinguishment is cooling the material below the ignition point. Water from straight streams is recommended if other suitable extinguishing agents are not available. Since using water usually results in explosive violence, apply the stream from a safe distance or from behind a suitable shelter.

Use of auxiliary equipment. There may be incidents where, because of time needed to complete the rescue operation, the extinguishing agents are totally used up. This usually occurs when the aircraft involved is a heavy transport, tanker, bomber, or other large aircraft. Before this occurs, you must bring the auxiliary equipment into use. Water tankers and structural pumpers can supply water to the aircraft firefighting equipment. The structural pumpers do this by laying hose lines from a source of supply to the crash equipment. Wreckers also may be used to move parts of the aircraft for more thorough extinguishment.

Exercises (012):

1. What are the principal points of concern during the attack phase?

2. What is the most widely used concept of attack for quick control?

3. What is the target area during an attack?

4. What does control mean in crash firefighting?

5. When does control of a fire start and how is it achieved?

6. Explain a backflash and the dangers it presents.

7. Why should you conserve the agent as much as possible during the control phase?

8. Ordinarily, when does complete extinguishment begin?

9. Give the three ways to identify the contents of tubing on an aircraft.

10. Describe the warning symbol used on aircraft tubing.

11. When should water be used on magnesium fires?

12. Match the tubing color in column A with the tubing's contents in column B by entering the correct number in the space provided:

Column A

a. Brown and orange.
b. Yellow.
c. Grey.
d. Orange and blue.
e. Red.
f. Green.
g. Orange.
h. Brown.
i. Blue and yellow.

Column B

1. Lubrication.
2. Breathing oxygen.
3. De-icing.
4. Fire protection.
5. Compressed gas.
6. Pneumatic.
7. Fuel.
8. Electrical conduit.
9. Hydraulic.

CHAPTER 4

Salvage and Overhaul

THE FIRE MUST BE extinguished rapidly to preserve as much property as possible. Your first consideration is to save lives and your second is to save property. The preservation of evidence should be the third most important thing to keep in mind. The sooner the fire is extinguished, the less chance there is that valuable evidence will be destroyed. You can start extinguishment at the edge of the burning area closest to the fuselage and the vehicles. Drive the fire forward and extinguish it with the turrets and handlines. Always direct the operation away from the aircraft, never toward it.

4-1. Salvage

The purpose of salvage work in crash firefighting is to prevent excessive damage by fire, smoke, and water. Salvage should start as soon as possible, depending upon the number of personnel available at the scene. If enough people are available, salvage operations can take place in conjunction with firefighting and rescue operations.

C13. Explain certain specific steps in salvage operations.

Protecting Internal Exposures. During control, a large degree of protection is given to the internal sections of the aircraft. At times, the aircraft should be entered for reasons other than personnel rescue. One reason is to prevent the overheating and possible detonation or destruction of weapons. The time factor is vital in such an instance. It is the time that a weapon can be safely exposed to the intense heat of the fire. If you can get into the bomb bay within the time margin and play a continuous stream of foam or water on the weapon, you may be able to cool it below the danger level. Water is by far the most efficient agent to use for cooling. Foam is also used for this purpose because of its water content, but the foam on the weapon must be renewed at frequent intervals to maintain the moisture content of the foam in contact with the metal of the weapon.

If there is a possibility that the fire around the aircraft cannot be extinguished, the firefighters should try to remove high value cargo to an area where it will be safe. If the fire can be extinguished and, after overhaul, the aircraft is declared safe, qualified explosive ordinance disposal personnel should enter and remove any weapons from the aircraft.

Take special care with other important sections of the aircraft. Try to prevent further damage to the cockpit, the flight deck, and the engineer's areas. These areas contain the instruments that can furnish a lead to the cause of the accident. If large quantities of foam are directed into these areas and allowed to dry, the corrosive action of the foam may remove the paint from the dial surface of the instruments. Other parts of the controls can be damaged by the action of the foam, and the investigating officers could come to a wrong conclusion. *Clean agents* are better extinguishing agents for the interior of the aircraft as long as no personnel are endangered.

The fuel tanks are another internal hazard and should be protected. Many aircraft carry large quantities of fuel in tanks in the fuselage. Extreme heat can cause them to rupture. If you know the location of these tanks on different aircraft and can control the fire around the fuselage areas containing them, you can prevent such ruptures. Preventing the rupture of these fuel tanks and limiting the amount of fuel involved will make your job of control and extinguishment much easier.

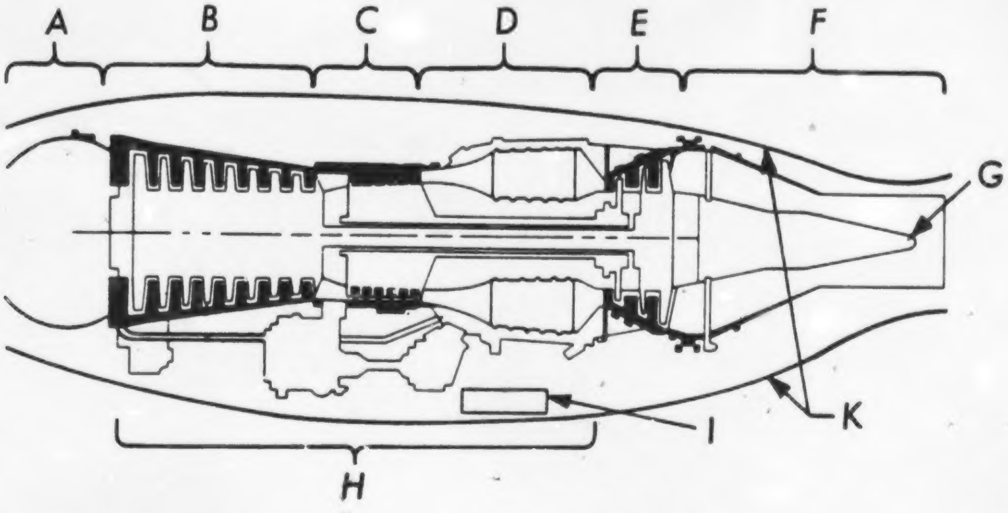
An external fire can penetrate the interior of an aircraft through open doors, windows, hatches, and ruptured skin surfaces caused by the accident. You can protect the interior by rapidly extinguishing the fire in the area next to the fuselage and then maintaining this fire-free area until extinguishment is complete.

Engine Fires. Usually, aircraft engine fires occur outside reciprocating engines and inside jet engines. Engine fires occur most often during the starting operation while the aircraft is parked.

Reciprocating engines. Whenever a reciprocating engine is involved in a fire, the most common cause is leaking gasoline. The fastest way to control and extinguish this type of fire is by the use of a clean agent. Short bursts from first-aid hand extinguishers or the P-13/P-13A are most effective and should not cause damage. By placing the horn of the hand extinguisher or the P-13 nozzle close to the front of the engine, you can normally extinguish the fire. If the fire is behind the firewall, you can knock out the engine cowling fire access door on the underside of the engine and discharge the agent at that point. After you extinguish the fire, qualified aircraft mechanics should remove the engine cowling in the presence of the fire department for a thorough inspection for burning material. The electrical power of the aircraft should be off or disconnected as soon as possible after the fire is discovered.

Jet engines. Generally, jet engine fires occur inside the combustion chamber, D, and turbine section, E, of the engine shown in figure 4-1, and are due to ignition and fuel problems. These fires do not usually constitute a grave hazard as long as the fire is confined to the combustion chamber. If the fuel supply to the engine can be turned off and power can be supplied to turn the compressor (B and C), the fire may be blown out. If you cannot extinguish the fire this way and the compressor is not rotating, apply a clean agent into the combustion chamber through the rear of the engine tailpipe, F. You may be able to put out the fire without damage to the turbine blades. Always stand at one side of the tailpipe to prevent being burned by erupting flames. As a last resort, the introduction of foam into the inlet duct, A, of the engine may extinguish the fire, but the cold agent can warp the hot blades in the compressor section, and the foam drying on the engine parts will necessitate a complete engine change and a subsequent engine disassembly for cleaning.

If the fuel supply cannot be stopped, the fuel will leak out of the combustion chamber or the turbine section through the drain holes and onto the ground. It may also leak into the engine nacelle, K, starting a fire around the engine. A fire in this area could do considerable damage because it will involve the accessories mounted on the engine, the electrical wiring, and the connectors for the fuel, engine oil, and hydraulic fluid lines. Each nacelle or engine cowling has a fire access knock-in door, I, that is easy to open. Ground personnel can usually reach these fire access doors easily (there is at least one for each



A. inlet duct.
B. low-pressure compressor section
C. high-pressure compressor section
D. combustion chamber
E. turbine section
F. tailpipe
G. exhaust cone
H. accessory section
I. fire access knock-in door
K. engine cowling or nacelle

Figure 4-1. Jet engine.

engine). The application of a clean agent through these doors is usually the most effective method of extinguishment. The agent will be in a reasonably confined space and it will remain there without adding to the damage caused by the fire. You may use foam, but the engine will have to be changed. It is better, however, to have a foam-drenched engine than to lose the whole aircraft.

The design of the aircraft determines where the fire access knock-in parts are located. It is your responsibility to know these knock-in locations for each aircraft on which you may fight fire. In aircraft with the engine or engines inclosed in the fuselage, the knock-in doors are usually near the top of the fuselage and in the central part of the engines accessory section, H. The knock-in doors in aircraft whose engines are mounted in pods are located at the bottom of the pod or nacelle.

Exercises (C13):

1. Why should you try to cool a weapon in an aircraft during firefighting operations?

2. What is the most efficient agent for cooling purposes?

3. When should firefighters move cargo from a crashed aircraft?

4. Who should remove the weapons from a crashed aircraft?

5. Why should you take special care when you are fighting a fire in a cockpit or on a flight deck?

6. Why should you know the location of the fuel tanks on an aircraft?

7. In an external fire, how can you prevent fire, heat, and damage to the inside of a crashed aircraft?

8. Where do aircraft engine fires usually occur?

9. What is the most common cause of fires involving reciprocating engines?

10. When should the electrical power of the aircraft be turned off when there is an electrical fire?

11. Jet engine fires do not usually constitute a grave hazard as long as they are confined to what area?

12. What should be your last resort in combating a jet engine fire?

13. Why will a fire inside a jet engine nacelle cause considerable damage?

4-2. Overhaul

After every crash (regardless of whether a fire has taken place or not), the firefighting crew is required to conduct a complete overhaul. In the overhaul operation, the crew members must be alert to considerations other than firefighting and fire protection. Insofar as possible, the firefighting crew member should not interfere with the investigation of the crash by accident officers, safety officers, or the board of officers. For the information of these officers, the fire chief in charge of the firefighting crews should itemize all the actions taken by the firefighting crews in the overhaul operation. Tampering with the aircraft should not be permitted under any circumstances, no matter how trifling it may appear to members of the firefighting crews. The operations officers, the accident officer, military guards, and other predetermined base officials should be present at every crash. The activities of the firefighting crews during overhaul should be fully coordinated with Air Force representatives.

C14. Cite significant actions in the overhaul operation.

Figure 4-2. Overhaul—cooling hotspots on aircraft 186.

The most important immediate action is placing all control switches, the ignition switch, the gun safety switch, and especially the master switch on the OFF position. The individuals detailed to this duty should make notes on the position of all the switches when they enter the cockpit/flight deck area.

You must cool all *hot spots*, as shown in figure 4-2, and open for inspection any areas suspected of containing hidden fire. This requirement does not give you a free hand to cut up the aircraft; remember—you must have reason for making each opening.

Batteries should be carefully disconnected. Battery connections usually lead to the battery housing through a sheath, ending in a terminal box. Remove this box cover and disconnect the cables from the battery, or remove the *quick disconnect* from the battery. After you have removed the ground wire, you can disconnect the other terminal with much less danger. This action eliminates any danger of arcing within the structure if you touch the grounded metal framework with a metal tool. Arcing can still occur, however, if a metal tool is shorted across the battery itself. After you have disconnected the battery, carefully tape or cover the terminals so that there will be no danger of contact. Remove the ground battery connection first if separate connectors are used.

The actual removal of the battery is unnecessary if the task is difficult or if it requires excessive time. The careful taping or covering of the battery terminals is, however, most important because, when the aircraft is moved, the motion may cause bare metal to touch the battery terminals, producing enough spark to ignite fuel vapors.

Fuel should be removed from the aircraft. With the pumps on a fuel truck or trailer, it is usually pumped from the aircraft tanks directly into the fuel-truck tanks. The aircraft tanks must be emptied with the greatest care and with every possible safeguard. Firefighting equipment, fully manned, should be stationed in position for immediate action if a fire occurs. At the conclusion of the pumping operation, replace all filler caps and closures to the openings in the fuel tanks. Fuel tanks, whether empty or containing fuel, are a serious hazard. If any fuel has spilled on the ground as the result of the crash or of draining the fuel tanks, this fuel should be heavily blanketed with foam to prevent its ignition.

All bombs, flares, signals, and ammunition must be removed from the aircraft to a safe place and placed under guard. The removal of radar equipment containing detonators or destroyers is not necessary from a fire-safety standpoint, but it is done by responsible personnel for security reasons.

An aircraft that cannot be removed immediately from the scene of the crash should be securely anchored by Air Force personnel, or under their supervision. Observing standard procedures in this operation will prevent further damage to the aircraft.

If there is no danger of fire damage, the fuel remaining on the ground after the aircraft has been moved away may be set on fire. It should be burned under the careful observation and control of firefighting crews. Unless this is done, the fuel may accidentally ignite from a carelessly discarded match or cigarette. If a crash occurs off the base or on privately-owned property, you must dispose of all remaining fuel to avoid any possibility of injury or damage to civilians. Claims against the Government can result from negligence in fuel disposal.

Policing the crash site is highly important when an aircraft is not moved away immediately. Military guards should be available for this duty, and the policing of the area should be coordinated with the base officials. They should be informed if there is danger of fire in the aircraft itself or in the vicinity. If the danger warrants, firefighters and equipment should stand by until the fire danger is eliminated. If large quantities of fuel are spilled on uneven terrain, all low areas must be policed. Until the aircraft and all equipment are removed from the crash site, smoking and the use of open flames for any purpose must be prohibited.

If the crash was followed by fire, the overhaul operation should be as complete as possible, depending upon the extent of the damage. If the aircraft was completely demolished, the site of the crash should be policed to protect on-lookers from fires that might develop as well as to help in the investigation of the accident. The firefighting crews must never, under any circumstances, assume that the job is finished simply because the fire has been extinguished. It is a part of their work to prevent other fires from starting and damaging Government or private property.

You may be asked to assist the investigators by moving certain items or by washing foam away from certain areas. Before washing away the foam blanket, be sure that the area is secure from possible ignition and that a back-up line with foam is on hand.

Preserving Evidence. You must watch the area around the crash site very closely. Small parts of the aircraft may be thrown for some distance from the aircraft's final resting place or scattered along its path of travel to the crash site. These small pieces or parts must be left where they are found unless responsible officials order them moved. A crash site is no place for souvenir hunters.

When they are firefighting and overhauling the aircraft, it is extremely important for all firefighters to look for, recognize, and preserve any evidence needed for further investigating. Be very careful and do not disturb any evidence that may aid the investigating officers in determining the cause of the accident or the extent of damage.

Shield any documents or material known to be classified from public view or photography. Move only those parts of the aircraft that must be moved for the performance of your duties, nothing more. Remember, do whatever is necessary to make sure that the wreckage is not moved or tampered with in any way, except to assist or remove persons injured or killed, and to eliminate any further danger. The investigating officers will be looking for evidence during the overhaul operations. Coordinate with these officers and assist them to the best of your ability. They are there for a definite purpose and are a part of the overall team.

The aircraft and all related parts should be washed down and neutralized with large amounts of water. To repeat, if the aircraft cannot be moved from the scene of the accident immediately, the fire department should detail a firetruck and crew to stand by and the security police will send a detail to guard against unauthorized persons in the area.

The senior fire officer at the scene controls the operation until the aircraft and the area are fire-safe. You, as a fire protection specialist, must relay any information in your possession to the senior fire officer present for its proper evaluation. If you are questioned, be sure to release your information only to authorized personnel.

Exercises (C14):

1. When are firefighting crews required to perform a complete overhaul of a crashed aircraft?
2. What is the most important immediate action that should be taken during overhaul?
3. What areas should be cooled during overhaul?
4. What is done with the fuel that remains in the tanks of a crashed aircraft?
5. What determines the extent of an overhaul operation?
6. What should be done with documents or materials that are known to be classified?
7. Which parts of an aircraft are you authorized to move during an overhaul operation?
8. Who exercises control over overhaul operations at a crash scene?
9. When you are questioned about a crash, how should you answer?

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Training and Duty Levels

DRILLS, DRILLS, DRILLS. "Why all the drills?" you ask. "I know my job." True, you know your present job but what about the next job up the career ladder or the one above that? If you don't know them, you should, and there is no better time than now to start learning them.

All of the *book learning* in the world won't make you a good firefighter, nor does knowing how to do certain tasks in fire protection. A good firefighter balances textbook knowledge and the ability to perform the tasks he studies about. You must be able to do a good job as well as talk a good job.

5-1. Drills and Training Exercises

Every drill that you take part in should have a specific purpose. Normally, a drill is held to evaluate an individual, a crew, or a department's response to a certain situation. Do not confuse drills with training exercises.

C15. Compare drills and training exercises.

Training Exercises. Training exercises are designed to teach a specific task or technique to an individual or a crew. These exercises should be well planned with adequate classroom and briefing time to insure that each individual involved knows exactly what is expected of him and the conditions under which the exercise will be conducted. Usually, several training sessions are conducted on a specific problem before a full-scale drill is held.

Drills. Drills are generally unannounced evaluations. Each individual must react to the situation as if it were the real thing and not just *make believe*. The drill site and conditions should be as realistic as possible to achieve maximum results. You can't expect to perform very effectively if you are told that a T-41 aircraft is a simulated B-52.

Drills can be conducted on almost any operation and under all sorts of conditions. Your main consideration is the safety of personnel and equipment. The more realistic the drill is, the more useful it will be as an evaluation exercise.

By now, you should be experienced in routine local crash firefighting and structural drills and know how they are conducted. But do you know what special drills are and what to expect from them? To start with, you should expect the unexpected. For this reason you should be trained in all the crew positions for the apparatus to which you are assigned. These special drills may test your department's reaction to a specific type of situation, such as an accident involving special weapons or an incident involving a large number of casualties. Special drills may also be conducted to determine how your department will operate for an extended period of time under difficult conditions. The drills may last from a few minutes to several days depending upon the purpose of the drill and the performance of the agencies taking part.

A few drills are held to evaluate the fire department only, but more often than not, drills are conducted to evaluate several supporting agencies (such as security police and medical support) at the same time. These joint purpose drills show the degree of proficiency of each of the agencies taking part, the amount of planning each has done for the possible emergency situations, and the ability of each responding agency to work in conjunction with the other agencies.

Normally, all aspects of the operation are evaluated at the same time. If an agency fails to perform satisfactorily, there will probably be a repeat of the drill after several training sessions. It is not uncommon for fire protection personnel to have to take part in a repeated drill because some "Klutz" from another agency didn't know how to do his job. Regardless of the reason for the drill, you should consider each one as a learning situation.

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Exercises (C15):

1. What is the difference between a training exercise and a drill?

2. Drills are conducted on what types of operations?

3. Why are *joint purpose* drills conducted?

5-2. Duty Levels

Throughout your career in fire protection, you will be in a learning situation—or at least you should be. Most of your learning will take place during drills and in other controlled training situations. Normally, you train to one position, and after you become proficient in that position, you move on to another.

C16. Explain training progression, and given a list of fire protection duties, match each duty to the correct position.

Training Progression. Most firefighters start out on the tail board and work up from there. In most cases, they start out as nozzlemen. Then they move on to hydrantman or *plugman*, then to driver-operator, and finally to crew chief.

If you were called upon, do you think you could perform as a driver-operator or crew chief of the apparatus to which you are assigned? If you stop and think about it, you probably could, allowing for a few mistakes, because you have watched the other members of your crew and you remember some of what they do. By taking a more active interest in these other crew positions, you can learn them much faster and become a much better firefighter.

Normal station activities are an excellent source of learning. As you do your own job, watch the others and help them. When your crew goes out to train or drill, ask for a dual-drill. The first part of the drill is to maintain proficiency in your current position and the second part is to try your hand at a higher position. You and your crew will spend a lot more time on drills but you'll learn more too. Learning is as much a part of your job as any other duty. You didn't *hire on* to sit around on your *duff* all day and watch TV or play cards. You hired on to learn a skill and do a job.

Since you are working toward your 5 level, you should be very interested in the type of jobs that you can look forward to in the future. First of all, we will list the tasks that you are doing now, and then look at some of the positions up the line.

Hoseman, nozzleman, or hydrantman. You should have the cross-trained capability to function as hoseman, hydrantman, or nozzleman on any assigned vehicle. Besides assisting the driver-operator in his inspection duties, you should:

(1) Keep apparatus, equipment, tools, clothing, and facilities in a clean and serviceable condition.

(2) Respond to emergencies as required.

(3) Suppress and extinguish fires and take necessary precautions to prevent rekindling.

(4) Exercise caution to avoid unnecessary damage, loss of property, and injury to yourself and others.

(5) Protect, at the scene of a fire, all evidence of the fire's cause.

(6) Wear protective clothing when participating in fires or hazardous situations, and when directed by higher authority.

Driver-operator. As a driver-operator, you will be expected to retain your knowledge and skills in the positions that you held previously and at the same time perform your own assigned duties and learn the duties of a crew chief. Each driver-operator:

(1) Must be able to perform functional inspections of assigned vehicles.

(2) Must perform operator maintenance and assist motor vehicle maintenance personnel where possible.

(3) Must be fully capable of operating assigned vehicles.

(4) Should be a graduate of, or scheduled to attend, the applicable vehicle operator's course.

Crew chief. As you move up to the crew chief's position, you must maintain your capability in the other crew positions, and:

(1) Supervise the inspection and maintenance of fire vehicles and equipment, insure the use of the standard vehicle inspection forms, and review them for adequacy and necessary continued action.

(2) Respond with your crew and equipment to emergencies.

(3) Insure the safe arrival of your vehicle, equipment, and personnel at the scene of the emergency, and direct the fire suppression and rescue efforts of your crew.

(4) If you are the first to arrive at the scene of an emergency, assume command until relieved by a more senior fire authority.

(5) Perform the station chief's duties when delegated to do so, or when directed by emergency conditions.

Specific duties. As you can see from these brief descriptions, each individual performs many tasks. We will make no attempt to identify every task that each member of every crew must accomplish. To do so would be to establish policy and that is not the intent of this course. The specific duties for a crew member vary from base to base and from crew to crew within a department. Normally, each station has a job description for each crew position and they may contain minor changes to suit individual crew chief requirements.

Whichever position you fill, do not get the idea that a "lower" position is beneath you and that you should not train and drill in any but your assigned position. Regardless of your position, you should be able to fill ALL lower positions and the position at the next higher level. Even those persons not assigned to operations should be able to perform operations duties. Though not required by Air Force regulations, fire-protection personnel should take an active crewmember's part in drills from time to time to maintain proficiency.

Exercises (C16):

1. Give the usual training progression in fire protection.

2. What is the best way to learn the duties of other crewmembers?

3. How can dual-drills help you learn other crew positions?

4. As a driver-operator on a firefighting vehicle, what jobs are you expected to know?

5. Which crew chief normally assumes command at the scene of an emergency?

6. How will your specific duties as a firefighting crewmember be determined?

7. What positions should you, or any firefighter, be expected to operate in during a drill?

8. Match the correct position in column B with each duty in column A.

Column A

___a. Perform inspections of assigned vehicles.
___b. Direct the rescue efforts of the crew.
___c. Keep equipment clean and serviceable.
___d. Perform station chief's duties if delegated.
___e. Assist motor vehicle maintenance personnel.
___f. Respond to emergencies as required.

Column B

1. Nozzleman.
2. Driver-operator.
3. Crew chief.

Bibliography

Department of the Air Force Publications

AFR 92-1, *Fire Protection Program.*

AFM 127-100, *Explosives Safety Manual.*

AFR 127-101, *Ground Accident Prevention Handbook.*

Commercial Manuals

International Fire Service Training Association (IF[illegible] Manuals,
1972—Oklahoma State University, Stillwater, Oklahoma.

NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you must request one item at a time on a loan basis from the AU Library, Maxwell AFB, AL 36112, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs*. TOs, classified publications, and other types of publications are *not* available. Refer to current indexes for the latest revisions of and changes to the official publications listed in the Bibliography. Refer to current indexes for the latest revisions of and changes to the official publication listed in the bibliography.

Answers for Exercises

CHAPTER 1

Reference:

CO1 - 1. Teamwork.
CO1 - 2. The type of aircraft involved, number of personnel on board, the nature of the emergency, amount of fuel remaining, type and amount of cargo, type and amount of ordnance, and any other information that can influence firefighting operations.
CO1 - 3. Firefighting crew members should be assigned definite duties and responsibilities.
CO1 - 4. All positions.
CO1 - 5. To allow for unexpected events.
CO1 - 6. The crew chief of the first unit to arrive is in charge until the arrival of the fire chief or assistant chief.
CO1 - 7. The pumpers supply water to the crash trucks, if needed, and the pumper crews assist in firefighting and/or rescue activities as required.
CO1 - 8. Fire protection personnel and personnel in maintenance, armament, medical services, and security police.

CO2 - 1. The airspace designated as a control area and/or control zone, within which air traffic control is exercised.
CO2 - 2. The prescribed route for aircraft when landing and taking off.
CO2 - 3. Against the wind.
CO2 - 4. Local conditions and the type of aircraft being flown.
CO2 - 5. The downwind leg—the first side of the landing pattern in which the aircraft is flying parallel to the active runway heading and toward the approach end of the active runway.
The base leg—a 90° turn from downwind (to crosswind), which places the aircraft at right angles to the active runway.
The final leg—a 90° turn from base leg, which places the aircraft in the direction of and in line with the active runway.
CO2 - 6. The aircraft does not fly a standard three leg approach but lines up with the active runway from some distance out and flies "straight-in" for a landing.
CO2 - 7. From their compass bearings.
CO2 - 8. 22.
CO2 - 9. Look to the west because the aircraft will be traveling from west to east on a bearing of 90°.
CO2 - 10. A bar is placed under the base of the numbers 6 and 9 to prevent confusion.
CO2 - 11. 30R.

CO3 - 1. Face the vehicle and point to the turret operator. Then point to the roof turret with one outstretched arm and to the spot where you want the stream directed with the other outstretched arm.
CO3 - 2. The crew chief will face your vehicle and point to you.
CO3 - 3. By extending his arms over the head and crossing them at the wrist.
CO3 - 4. Stand still and wait for further directions.
CO3 - 5. Point to that operator and hold one arm in a horizontal position across your chest, patting the top of your horizontal arm with your free hand.
CO3 - 6. A dispersed foam barrel stream.
CO3 - 7. So that you may react at once if someone is in trouble or is indicating that he is getting hot.

CO4 - 1. Mostly wheels-up landings and defective landing gear.
CO4 - 2. A reduction in the extent of damage to the aircraft; a reduction in deceleration forces; extinguishment of any sparks caused by friction; reduction in fuel spill hazard; and a favorable psychological effect on the pilot, crew, and passengers.
CO4 - 3. The nature of the emergency, estimated airborne time remaining, hazardous cargo aboard, quantity of fuel, and number of crew and passengers.
CO4 - 4. The water content.
CO4 - 5. At least 0.1 gallon per square foot.
CO4 - 6. Protein.
CO4 - 7. The correct amount of water per square foot.
CO4 - 8. 4 minutes; 1 hour.
CO4 - 9. Base operations officer; fire chief; aircraft commander.
CO4 - 10. The type of emergency, type of aircraft, amount of agent available, and the time available.
CO4 - 11. Major pieces of firefighting equipment, such as the P-2 and P-4.
CO4 - 12. The individual operation; the tachometer.
CO4 - 13. By the use of special civil engineering equipment, such as hard surface sweepers or scrapers.

CHAPTER 2

CO5 - 1. A calculated risk.
CO5 - 2. Mild, moderate, and severe.
CO5 - 3. A mild fire risk.
CO5 - 4. By the proper placement of appropriate portable or mobile fire extinguishers.
CO5 - 5. The airfield ramp fire truck or one major piece of equipment if the ramp truck is not available.
CO5 - 6. A moderate fire risk.
CO5 - 7. One major piece of equipment.

C05 - 8. A class III fuel spill.
C05 - 9. At preselected positions along the active runway.
C05 - 10. The locations vary with circumstances and bases. They may be within or in front of the fire station, on the parking apron or handstand, or at some other strategic location on the airfield. The fire chief determines the specific location.

C06 - 1. When patients are on board.
C06 - 2. One fully manned major piece of equipment.
C06 - 3. From the time it lands until after takeoff, as long as there are patients on board.
C06 - 4. Between the fueling operation and the main avenue of escape.
C06 - 5. While patients are being on- or off-loaded.
C06 - 6. The aircraft commander.

C07 - 1. Usually carelessness or system malfunction.
C07 - 2. Any place where fuel is used, transferred, or handled.
C07 - 3. There is no way of preventing the vapors from reaching a source of ignition.
C07 - 4. Dry, warm, windy periods of weather.
C07 - 5. An oil- and water-absorbing compound should be used to remove the spills and the agency responsible for the spill must remove it.
C07 - 6. Less than 2 feet in any plane dimension.
C07 - 7. A class II spill involves an area not over 10 feet in any plane dimension, or not over 50 square feet in area, and is not of a continuing nature.
C07 - 8. The posting of a fire guard and the immediate notification of the fire protection organization. Sufficient equipment must be dispatched immediately to neutralize the spill. Necessary action must be taken to eliminate the hazardous conditions.
C07 - 9. When it meets the criteria for a class III spill, i.e., over 10 feet in any plane dimension and over 50 square feet in area, and of a continuing nature.

C08 - 1. To detect unsafe conditions.
C08 - 2. To locate, identify, and correct any unsafe condition or hazard before it develops into an accident or incident.
C08 - 3. The authorities responsible for that specific function.
C08 - 4. The fire chief.
C08 - 5. The individuals working in an area cannot predict when you will be there and will not change their work habits accordingly.
C08 - 6. You may make them more aware of the proper procedures to follow, causing them to perform safely.

CHAPTER 3

C09 - 1. Upwind.
C09 - 2. Distance and time.
C09 - 3. Assign crewmembers as *watchers*.
C09 - 4. The aircraft may take an unexpected path along the runway.
C09 - 5. As fast as base directives and conditions permit without sacrificing safety.
C09 - 6. To spot anyone who may have jumped or been thrown out of the aircraft before or after it stopped.
C09 - 7. Your department's operating instructions.

C10 - 1. The turret and handline streams will reach the farthest and there is less danger to your vehicle and crew.
C10 - 2. Only when there is no other safe way to fight the fire.
C10 - 3. When it is wet or covered with snow.
C10 - 4. When the position of the aircraft on the terrain must be considered.
C10 - 5. Plan your approach to the left side of the aircraft.
C10 - 6. To the rescue side.
C10 - 7. A long straight-in approach is generally better than a short approach with a lot of maneuvers.
C10 - 8. The crew chief of the vehicle.

C11 - 1. Weather, wind, terrain, type of aircraft, and number of trucks available.
C11 - 2. "First truck in splits the fuselage."
C11 - 3. There are no hard and fast rules for the positioning of vehicles.
C11 - 4. The turrets on the vehicles.
C11 - 5. The first truck positions on the nose or tail, the second on the rescue side, the third truck on the off-rescue side, and so on.
C11 - 6. The armament the aircraft may have.
C11 - 7. Consult TO 00-105E-9.
C11 - 8. To the front of the missile at an angle of 45° from the longitudinal axis.
C11 - 9. At a *safe* distance.
C11 - 10. Only the circumstances of the incident and your judgment can answer that.
C11 - 11. One P-2 on each side of the nose with the third P-2 on the primary rescue side. The P-4s should be positioned outboard of the P-2, one on each side.

C12 - 1. The probable location of personnel trapped within the aircraft and the location of access doors or points of forcible entry.
C12 - 2. Volume (mass) application of agent from turrets, with minimum use of handlines.
C12 - 3. The aircraft fuselage.
C12 - 4. Opening and maintaining a rescue path.
C12 - 5. Control starts during the approach by using turrets.
C12 - 6. A backflash is the reignition of fuel vapors after the fuel has been covered with foam. A backflash can surround or engulf anyone within the area at nearly explosive speed.
C12 - 7. The agent on your truck may be the only supply for the entire operation and the rescue path must be maintained until all personnel are freed and clear of the danger zone.
C12 - 8. When the rescue operation has been completed.
C12 - 9. Colors, words, and geometric designs (symbols).
C12 - 10. The warning symbol is a skull and crossbones.
C12 - 11. When other suitable agents are not available.

C12 - 12. a, 8
b, 1.
c, 3.
d, 6.
e, 7.
f, 2.
g, 5.
h, 4.
i, 9.

CHAPTER 4

C13 - 1. To prevent its overheating and possible detonation or destruction.
C13 - 2. Water.
C13 - 3. When there is a possibility that the fire around the aircraft cannot be completely extinguished.
C13 - 4. Only qualified explosive ordnance disposal personnel.
C13 - 5. To prevent further damage in those areas.
C13 - 6. So you can protect those areas from high heat and prevent their rupture.
C13 - 7. By keeping the fire away from the fuselage where there are open doors, windows, hatches, and exposed interior sections.
C13 - 8. Outside reciprocating engines and inside jet engines while the aircraft are parked and the engines are being started.
C13 - 9. Leaking gasoline.
C13 -10. As soon as possible after the fire is discovered.
C13 -11. The combustion chamber.
C13 -12. The introduction of foam into the inlet duct.
C13 -13. Because it involves the accessories mounted on the engine, the electrical wiring, and the connectors for the fuel, engine oil, and hydraulic fluid lines.
C14 - 1. After every crash (regardless of whether a fire has taken place or not).
C14 - 2. The placing of all control switches in the OFF position.
C14 - 3. All *hot spots.*
C14 - 4. It must be removed and disposed of properly.
C14 - 5. The extent of damage to the aircraft itself.
C14 - 6. They must be shielded from public view or photography.
C14 - 7. Only those parts of the aircraft that you must move for the performance of your duties and those parts whose movement is directed by proper authorities.
C14 - 8. The senior fire officer at the scene.
C14 - 9. Give your information to authorized personnel only.

CHAPTER 5

C15 - 1. Training exercises are designed primarily to teach; drills are used for evaluation.
C15 - 2. Any type of situation that may be anticipated.
C15 - 3. To evaluate the operation and planning of each of two or more agencies and the way the agencies work together.
C16 - 1. Hoseman, nozzleman, hydrantman, driver-operator, and crew chief.
C16 - 2. Take an active interest in the other crew positions during normal station activities.
C16 - 3. By keeping you proficient in your present duty position on the first drill and allowing you to perform in a higher position on the second.
C16 - 4. Your own as driver-operator, those that you have held in the past and the one just above the one you hold at the present.
C16 - 5. The first to arrive.
C16 - 6. By local directives and your individual crew chief.
C16 - 7. The position in which you are presently assigned and those below that level.

C16 - 8. a. - 2.
b. - 3.
c. - 1.
d. - 3.
e. - 2.
f. - 1, 2, and 3.

NOTE: Page Number 720 has been omitted.
However, all course material is included.

STOP-

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

57150 07 21

AEROSPACE VEHICLE FIREFIGHTING

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers.* The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (C01) Teamwork in firefighting operations should start with

   a. attendance at a formal fire protection school.
   b. developing a positive attitude in the individual.
   c. teaching the individual to operate effectively under any condition.
   d. training each crewmember to perform all the crew positions on the vehicles assigned.

2. (C01) If you, as an Airman First Class crew chief of a P-4, are the first to arrive at the scene of an aircraft accident, followed by the P-8 with a Staff Sergeant crew chief, a P-2 with a GS-6 assistant chief and the Base Operations Officer, who will be in charge until the chief arrives?

   a. The Base Operations Officer.
   b. The P-8 crew chief.
   c. The P-2 assistant chief.
   d. You, the P-4 crew chief.

3. (C01) Usually, the deciding factor between success or failure of a crash firefighting operation is

   a. changing vehicle positions by the fire chief after he arrives at the scene.
   b. the ranking man taking charge and directing the operation.
   c. the degree of cooperation between crash and pumper crews.
   d. the initial plan of attack.

4. (C02) If the control tower notified you that an aircraft would be landing on runway 18 with a fire in cockpit, the aircraft would be making a straight in approach to the runway from the

   a. north.
   b. south.
   c. east.
   d. west.

5. (C02) If your base has only one runway and the aircraft has been landing on runway 31 all day, what runway will be the active runway after the control tower notifies you of a runway change?

   a. 49.
   b. 22.
   c. 13.
   d. 09.

6. (C02) When an aircraft is on the first leg of a landing approach and is headed toward the approach end of the runway, what is the name of that landing leg?

   a. Dog leg to final.
   b. Base.
   c. Final.
   d. Downwind.

7. (C03) If you, as a crew chief, want the turrent operation to decrease the pump pressure on your vehicle, you should first point to him and then

   a. make a lowering motion with both of your hands outstretched in front of you.
   b. draw your right hand across your throat in a cutting motion.
   c. rapidly cross and uncross your arms above your head.
   d. pat the top of your hood with your left hand while slowly lowering your right arm to your side.

8. (C03) If you, as a turret operator on a P-2, see a crew chief point to you and then raise a hand above his hood, and then make a counterclockwise rotating motion with the raised hand, you would respond by

   a. increasing the pump pressure.
   b. decreasing the pump pressure.
   c. changing the roof turret stream to a straight stream.
   d. going to the crew chief to assist in the rescue operation.

9. (C03) If you, as a crew chief, point to a turret operator and then cross your arms at the wrist over your head, you are signaling the turret operator to

a. shut down the fire pump.
b. stop the flow of agent from the turret.
c. cool you off using two foam barrels.
d. let you know how much agent remains to be discharged.

10. (C03) If you as a handlineman, see your crew chief point to you, raise his right arm horizontally, and then tap the underside of his right arm with his left hand, you should

a. cool your crew chief's arm.
b. switch your handline nozzle to the water barrel.
c. increase the angle at which you are holding the nozzle.
d. check to see if there is a fire under the right side.

11. (C04) Once you have properly foamed a runway, the foam should keep its effectiveness for up to

a. 20 minutes.
b. 45 minutes.
c. 60 minutes.
d. 90 minutes.

12. (C04) To lay a foam blanket 16 feet wide and 2400 feet long will require how much foam if a 6 percent mixture is used?

a. 195 gallons.
b. 230 gallons.
c. 305 gallons.
d. 380 gallons.

13. (C04) How much water would be required to lay a foam blanket 8 feet wide and 2,200 feet long?

a. 2,200 gallons.
b. 1,990 gallons.
c. 1,760 gallons.
d. 1,510 gallons.

14. (C04) How long should it take to lay a 25,000 square foot foam strip on a runway using a 2,500-gallon water distributor equipped with a 500 gpm pump?

a. 3 minutes.
b. 5 minutes.
c. 8 minutes.
d. 10 minutes.

15. (C05) The airfield ramp fire truck should be dispatched to provide adequate fire protection for

a. a Class III fuel spill.
b. mass engine starts and/or movement of aircraft.
c. touch-and-go landings by trainer type aircraft.
d. up or down loading of weapons under normal conditions.

16. (C05) Mass aircraft engine starts and movements are considered to be in which one of the following risk values?

a. Mild.
b. Common.
c. Moderate.
d. Severe.

17. (C05) What are the minimum requirements for adequate fire protection for life risks?

a. One major piece of equipment.
b. The airfield ramp fire truck.
c. The rescue vehicle and one major piece of equipment.
d. All available equipment with full crews.

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18. (C05) A crew and vehicle in position on a hardstand to monitor normal flying is on

a. nonemergency standby.
b. emergency standby.
c. selective response.
d. standby.

19. (C06) Who gives permission for the refueling of aeromedical evacuation aircraft while patients are being on-loaded or off-loaded?

a. The fire chief.
b. The base operations officer.
c. The aircraft commander.
d. These two operations are never permitted at the same time.

20. (C06) Whenever possible, an aeromedical evacuation aircraft will be positioned so that the main avenue of escape will be

a. upwind.
b. downwind.
c. facing the standby truck.
d. on a slight slope toward a ramp drain.

21. (C06) If an aeromedical evacuation aircraft must be refueled with patients on board, the standby vehicle should be positioned

a. at a 45° angle to the left side of the nose.
b. at a 30° angle to the trailing edge of the right wing tip.
c. centered on the tail of the aircraft at a distance of 150 feet.
d. between the fueling operation and the main avenue of escape.

22. (C07) The best action to take when there is a large fuel spill under an aircraft is to

a. flood the entire area with a large amount of water.
b. have the aircraft which is affected towed to a safe area and wash the spill down with at least one P-2 load of water.
c. foam the spill, have the aircraft towed from the area, and wash the foam and fuel to a safe area.
d. have all aircraft in the area towed away and then wash the area down with water.

23. (C07) A Class II small fuel spill is a spill which is

a. less than 2 feet in any plane dimension.
b. less than 10 feet in any plane dimension.
c. of more than 50 square feet in area.
d. 1.5 feet wide and 3.2 feet long.

24. (C07) To be classified as a Class III large spill, the spill must have an area of over how many square feet?

a. 1,000.
b. 500.
c. 100.
d. 50.

25. (C08) How many personnel should be assigned to a roving patrol vehicle?

a. One.
b. Two.
c. Three.
d. Four.

26. (C08) The best route to take while making a roving patrol of an aircraft parking ramp is a

a. random pattern that no one could figure out.
b. counterclockwise rotation of the area at specific intervals.
c. zig-zag pattern passing any given point from opposite directions once every 20 minutes.
d. clockwise rotation of the area allowing 30 minutes for each complete rotation.

27. (C09) To guard against the danger of a collision between your vehicle and a moving aircraft while responding to an emergency, you, as the crew chief, should

a. assign crewmembers as watchers to warn the driver of impending danger and control tower light signals.
b. instruct the driver to move to the right of the route and reduce his speed to a safer level.
c. inform the control tower of your intended route of travel and request that all aircraft be instructed to stay clear of that route.
d. have your driver follow the chief's vehicle at a safe distance and ensure there is adequate height clearance.

28. (C09) By watching the terrain closely for crewmembers who have jumped or who have been thrown clear of the aircraft before it stopped, you are sometimes able to determine the

a. number of aircrew members remaining in the aircraft
b. number of rescue team members who will have to go into the aircraft.
c. location of any remaining crewmembers within the aircraft.
d. extent to which firefighting operations must progress to effect rescue.

29. (C10) Which one of the following statements concerning an upwind approach to a crashed aircraft will always be true?

a. The danger to personnel trapped inside the aircraft will be lessened.
b. The turret and handline streams from the trucks will reach the farthest.
c. The danger from armament loads carried by the aircraft are minimized.
d. The terrain features will be an aid to firefighting and rescue operations.

30. (C10) Generally, what type of approach is best to use on a crashed aircraft?

a. A clockwise circling approach from the left.
b. Short run-in from a "box" or square approach.
c. A long straight-in approach with few maneuvers.
d. The downwind rectangular approach as used by pilots.

31. (C10) When the type of aircraft involved in a crash is known, your approach to the site should be from the

a. nose of the aircraft.
b. right side of the aircraft.
c. left side of the aircraft.
d. rescue side of the aircraft.

32. (C10) When making an approach to a crash site, the person responsible for determining the order of precedence for the approach is the

a. senior fire official.
b. ranking man responding.
c. crew chief of the first truck in.
d. individual who prepared the prefire plan.

33. (C11) The second truck in on a crashed aircraft should normally be positioned

a. at the tail of the aircraft.
b. to the left of the first truck.
c. on the nose of the aircraft.
d. on the rescue side of the aircraft.

34. (C11) When positioning a fire fighting vehicle on an aircraft carrying missiles, what should be the angle between the fire fighting vehicle and the longitudinal axis of the missile?

a. 30°.
b. 45°.
c. 60°.
d. 90°.

35. (C11) The least important factor when positioning firefighting vehicles at the scene of an aircraft crash is the

a. amount of fuel on board.
b. wind direction and velocity.
c. location of aircrew members/passengers.
d. condition of the terrain and its features.

36. (C12) The principal points of concern in the attack of a fire involving a crashed aircraft are the

a. volume of agent available for application and the rate at which it can be applied.
b. probable location of personnel trapped within the aircraft and the location of access doors or points of entry.
c. positioning of the vehicles and the number of personnel available for rescue duty.
d. number of personnel in the aircraft and the extent of their injuries.

37. (C12) When does the initial attack on an aircraft crash fire start?

a. During the preplan stage.
b. During the approach.
c. After the trucks are positioned.
d. When the handlines are pulled.

38. (C12) Opening and maintaining a rescue path to the fuselage of a crashed aircraft is known as

a. attack.
b. positioning.
c. control.
d. extinguishment.

39. (C12) Ordinarily, complete extinguishment is not attempted until

a. all responding vehicles are in position.
b. the first three trucks in have been resupplied.
c. all available manpower is on the scene.
d. the rescue operation has been completed.

40. (C12) The three ways to identify the contents of tubing in an aircraft are

a. colors, words, and symbols.
b. colors, numbers, and designs.
c. symbols, letter codes, and pictures.
d. dots and dashes, colors, and numbers.

41. (C13) When foam is used to cool a weapon during a fire, it must be renewed at frequent intervals in order to

a. keep a high moisture content of the foam in contact with the metals of the weapon.
b. prevent the foam from baking onto the weapon case.
c. prevent the foam from drying out and starting a corrosive action on the weapon case.
d. provide a blanket of foam thick enough to insulate the weapon from the radiant heat.

42. (C13) Any weapons that may be involved in an aircraft crash should be removed by the

a. firefighters.
b. aircraft maintenance personnel.
c. accident investigation board of officers.
d. explosive ordnance disposal personnel.

43. (C13) The most common cause of fires involving reciprocating engines is

a. electrical malfunctions.
b. broken oil line.
c. leaking gasoline.
d. overheating.

44. (C13) The number of fire access doors for each jet engine on an aircraft is usually

a. one.
b. two.
c. three.
d. four.

45. (C14) When you start the overhaul of a crashed aircraft, you must first

a. disconnect the batteries.
b. cool all the hot spots.
c. flood the fuel tanks with foam.
d. place all control switches and the master switch in the OFF position.

46. (C14) The completeness of an overhaul following an aircraft crash and fire will depend upon the

a. extent of damage.
b. magnitude of the fire.
c. type of aircraft involved.
d. necessity for investigation.

47. (C14) Why must the wreckage of a crashed aircraft be protected?

a. To limit the chance of compromising security.
b. Because parts of the wreckage may identify the cause of the accident.
c. Parts may assist medical personnel in identifying the crewmembers.
d. Parts will help the fire chief to evaluate the effectiveness of the firefighting operations.

48. (C14) The senior fire officer at the scene of an aircraft crash should release his control of the area when the

a. first trucks leave the area.
b. base operations officer declares the area secure.
c. area is declared "fire-safe."
d. control tower operator orders all crash equipment out of the area.

49. (C15) To achieve maximum results from a drill, the site and conditions should be

a. made as realistic as possible.
b. so arranged as to not conflict with normal base operations.
c. prepared so that the operation can be completed in a minimum amount of time.
d. planned to take into account the training received by all of the various activities taking part.

50. (C15) Special drills will not be conducted to

a. determine how well your department has been trained for handling incidents, involving a large number of casualties.
b. determine how well your department can operate for extended periods of time under difficult conditions.
c. test your department's reaction to an accident involving special weapons.
d. train newly assigned personnel to their crew positions.

51. (C16) Supervising the inspection and maintenance of fire vehicles and equipment is the responsibility of the

a. driver.
b. crew chief.
c. station captain.
d. assistant chief of operations.

52. (C16) Normally, the driver-operator of a firefighting vehicle would be expected to perform best in which one of the following positions?

a. Fire chief.
b. Station chief.
c. Crew chief.
d. Handline/nozzleman.

53. (C16) As a crew chief, you may expect to perform the station chief's duties

a. only after you have been upgraded to the 7 level.
b. when delegated or when directed by emergency conditions.
c. on a normal rotational basis during all drills involving your crew.
d. during special drills conducted to upgrade the overall department fire protection rating.